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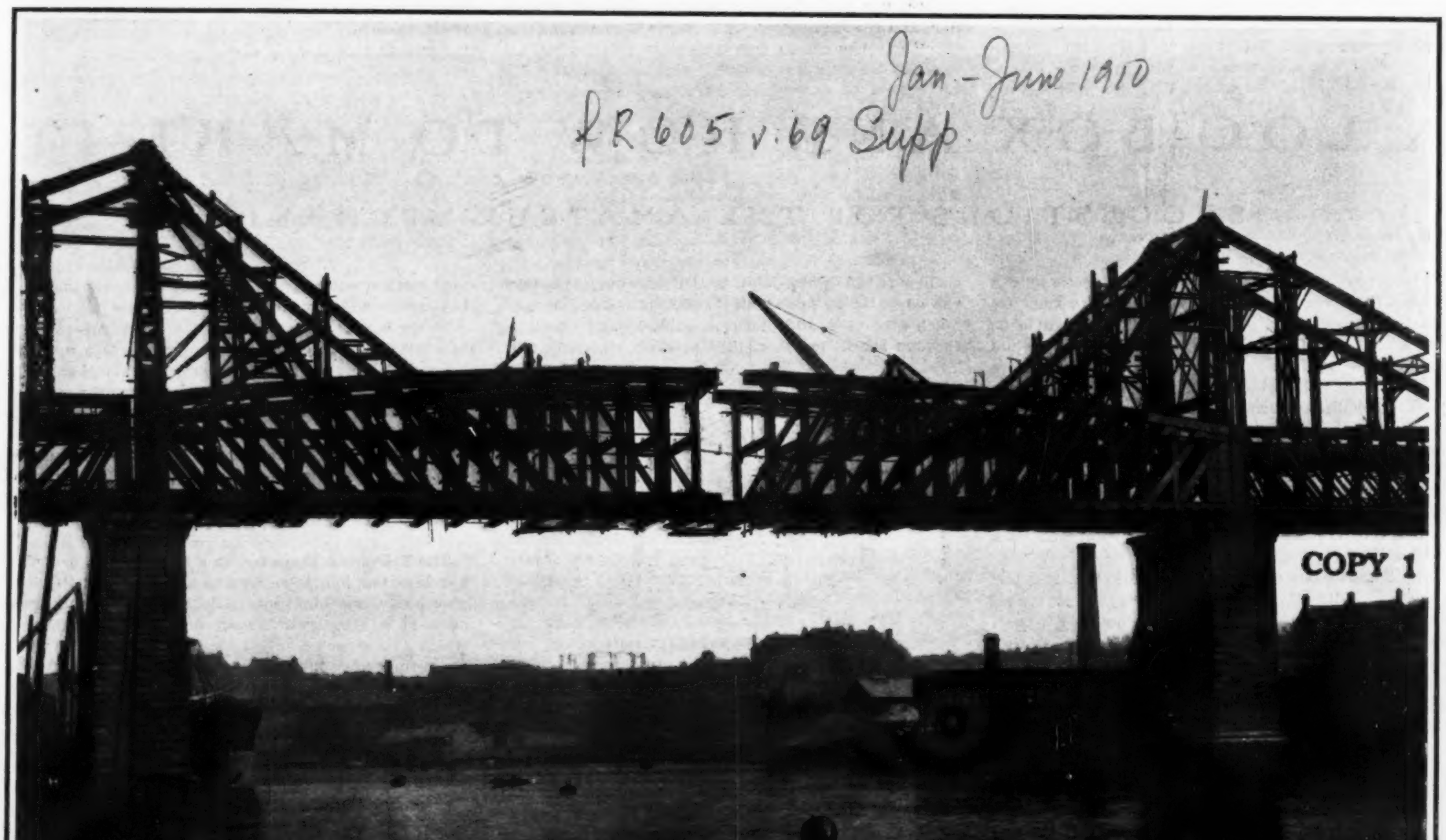
THE DOUBLE-DECK BRIDGE ACROSS THE WEAR RIVER WITH ITS APPROACHES.



CONNECTING UP THE CENTRAL SPAN OF THE WEAR RIVER BRIDGE.

THE DOUBLE-DECK BRIDGE OVER THE WEAR.

THE DOUBLE-DECK BRIDGE OVER THE WEAR.

A COMBINED RAILWAY AND HIGHWAY BRIDGE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A LARGE double-deck bridge has been constructed over the River Wear, England, to accommodate both railroad and highroad traffic. The town of Sunderland, numbering some 150,000 people, is fairly evenly divided between the two banks of the river. For several years the necessity of improved communication between the opposite banks has been felt. At last the various surrounding local bodies, the town of Sunderland, and the North-Eastern Railroad decided to combine in the erection of a large bridge suited to all classes of traffic. The outcome was the erection of the massive bridge shown in the accompanying illustrations. The lower deck is restricted for pedestrian and vehicular traffic, and is practically the property of the Sunderland municipal authorities, while the upper deck carries the railroad track, and is the property of the railroad.

The erection of a bridge at the point desired was no easy matter. The shipping traffic on the waterway demanded that ample headway should be provided for vessels, and that the construction should be so carried out as not to interfere with the launches from the shipbuilding yards on either side. The designing of the structure and the whole of the subsidiary work in connection therewith were carried out by Mr. Charles A. Harrison, D.Sc., the chief engineer to the North-Eastern Railroad. His design comprised a bridge 1,220 feet in length between abutments, composed of three shore spans, each of 200 feet, and a main river span 330 feet long and 85 feet above high water. In addition there was much very heavy approach work, since the railroad, to gain the bridge, has to be carried at a high level. The lower deck has an over-all width of 64 feet, there being a projection of some 13¾ feet on either side of the main girder, carrying a 7-foot sidewalk and a 5-foot space for gas and water mains, the transoms being cantilevered out on each side for this purpose. The clear width of the roadway within the bridge is 26 feet, with a clear height between the surface of the road and the under side of the railroad deck of about 14 feet. On the shore spans the girders are 30 feet in height throughout, while in the case of the river spans, the ends are 30 feet in height, curving to 42 feet in height at the center. The railroad deck carries a double track.

The contract was secured by Sir William Arrol & Co., Ltd., the builders of the Forth Bridge, to whose courtesy we are indebted for the accompanying illustrations. Constructional work was commenced early in 1905. The piers are built of granite, those for the river span being 48 feet wide, above the plinth, by 25 feet in thickness. They are built in two rectangular shafts 16 feet in width, connected at the top by an arch. On the south side the pier is carried on a steel caisson measuring 63 feet in length by 35 feet wide and 44 feet deep, and sunk to a depth of 75 feet below high-water mark, by superimposed weight, the material within being excavated under compressed air. The work was so carried out that the top level of the masonry superstructure was kept just above high-water mark, so that the necessity of a cofferdam was avoided. The height of the pier from foundation to coping level is 170 feet. The pier on the north bank rests upon a concrete foundation, which was laid within a timber cofferdam.

The erection of the shore spans was carried out rapidly and uneventfully, and it was in connection with the main river span that the greatest difficulty arose. The traffic on the waterway precluded the possibility of carrying out this section other than upon the "overhang" system, the girders being carried out member by member from either side, and finally connected up in the center.

The method by which this was accomplished is clearly shown in the accompanying illustrations. The main bearings of the river span were first set in position, and the first pieces of the lower booms laid. The end vertical members were placed in position. When their correct position and other adjustments were effected, packing steel blocks were inserted between the main girders of the shore and river spans in such a manner as to secure an even distribution of the strains. The upper booms were temporarily connected to the shore span. When the adjustments had been completed the diagonal members of the bay were erected as well as the flooring, to secure lateral stiffness. Temporary steel towers were then erected on each pier above the end members of the spans, and anchored to the shore span as illustrated, these towers being 70 feet in height. As the overhanging section proceeded outward, the weight was supported by means of ties. This was the procedure successfully adopted in the erection of the Forth Bridge. The greatest load to which any one set of supporting ties attached to one girder was subjected amounted to 710 tons. Successive bays were erected in this manner until the two overhanging sections had approached each other to within 8 feet.

The top and bottom booms of each girder are 4½ feet wide by 3½ feet deep, and the lattice framework wind bracings are spaced 24 feet apart between the top booms about 3¾ feet deep. The girders are divided into panels by vertical members spaced 12 feet apart. The total weight of a single girder in the river span is 960 tons, and altogether about 8,500 tons of steel work have been worked into the whole structure.

In the official tests prior to the opening of the bridge, under a load of twelve locomotives representing nearly 1,200 tons, the river span showed a deflection of about 1 inch. The lower deck will carry a street railroad track for the electric cars of the Sunderland Corporation, which contributed $730,000 toward the scheme, as well as the provision of a considerable extent of necessary land, while the total cost of the bridge was approximately $2,250,000. In addition to the bridge itself, there are nearly two miles of approach for the railroad to gain the high level.

A LOG BOX AND HOW TO MAKE IT.

SUGGESTIONS FOR THE AMATEUR MECHANIC.

A LOG BOX, unlike a coal box, is not necessarily a piece of furniture for the dining or drawing room. To suit the purpose it is intended for, it is bound to be roomy, or it would be useless, so that a log box pure and simple is no ornament to a room. The idea we have in view is to combine the advantages of a log box with those of a hall stool or seat, and this we show in Figs. 1 and 2. It should, if possible, be made of oak, or failing that, American whitewood can be stained oak color, and makes a very good substitute. There is nothing intricate in the construction; it wants to be strong, of course, and no joints should be obtrusive. In order to accomplish this end, the front and back are let into grooves.

Fig. 3 shows one of the sides. The height is 2 feet 3 inches, width at bottom 15 inches, and at top 12 inches, made out of ¾-inch wood, or not less than ⅝ inch. Fig. 4 shows the front (or back piece, as they are both alike), with the ends cut in the form of a shoulder or rebate, to let into the grooves in the sides. It measures 18 inches square, not including the rebates. The grooves for the bottom of the box come 3

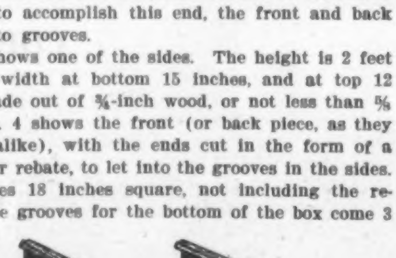


FIG. 1.—GENERAL VIEW.

inches from the floor line, and instead of cutting a shoulder in the bottom board, bevel the edges down on both sides to fit. If ¾-inch wood is used, the grooves should be ½ inch wide and nearly ½ inch deep; and if thinner wood is used, they must be proportionately less. The width necessitates a joint in each part. A glued joint is strong enough, provided the edges to be joined are "shot" quite true, not too much glue used, and that well rubbed out by working the two boards together, then securely clamping until

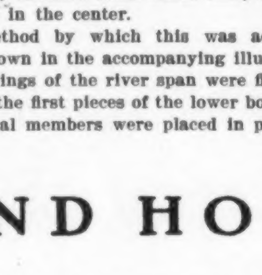


FIG. 2.—SHOWING LID OPEN.

quite set. The hollows at the bottom are cut out with a frame saw, and the heart-shape holes with a keyhole saw, having first prepared an opening with a twist bit.

To put the parts together, lay one side on the floor face downward, glue in the front and back, slide the bottom in (gluing it also), and then fix the other side on, seeing that there is no twist in the box before the glue sets, and finally binding it tightly round with strong cord.

When set, fix a 2-inch malleable iron bracket (one that has no stay) to each corner inside, and underneath the bottom glue several small blocks of wood.

The seat is 15 inches wide, with the grain of the wood running at right angles to the front; the flap or lid is 15 inches long, and the fixed part 3 inches, the lid being hung with a pair of 2-inch brass butt hinges.

To fix the 3-inch part of the seat, drill a ⅜-inch hole with a twist bit through it into the front and back of the box, then fit and glue in wooden pegs of the same material, and also glue two or three small wood blocks underneath to the side of the box. The arm rests or caps for the sides are 14 inches long and 1½ inches wide, grooved underneath and glued on.

If the box is made of oak, as a finish rub in some raw linseed oil, and repeat the process two or three times until the oil is well rubbed in; but if made of whitewood, get some oak water stain (not varnish stain) and apply it with a piece of sponge, allowing one coat to dry well before putting on a second, the number of applications depending upon the shade required; then rub in the oil as directed above, and the result will be infinitely better than varnish.—The Woodworker.

The Telephone Engineer, in a recent issue, describes a relay that has been devised for use with the telephone receivers of wireless telegraph systems. It consists of a step-down transformer, the secondary of which is connected to an electrolytic detector, while the primary is connected to a telephone receiver. The former has a resistance of 450 ohms, and the latter a resistance of 3 ohms. One end of a carbon rod rests

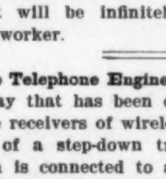


FIG. 3.—VIEW OF END.

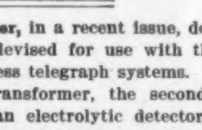


FIG. 4. FRONT OR BACK.

on the diaphragm of the telephone receiver, while the opposite end engages a carbon block, thus forming a microphone. The second telephone is placed in circuit with this microphone and a battery, and thus reproduces the "wireless" signals so loudly that they can be heard throughout a large room.

THE HORSE-POWER OF A WATERFALL.*

HOW TO DETERMINE THE VALUE OF A WATER POWER.

BY W. T. RYAN.

UP to a few years ago water powers were usually bought for a "song," and water wheels were installed, as the business increased, without first ascertaining the actual horse-power of the stream. Now, however, the available power has increased in value to a point where both owners and users find it desirable to determine beforehand, as nearly as possible, how much power there is available.

It is the purpose of this article to point out the principal things the owner or purchaser should know, and to present simple methods for making an estimate of the available power.

The first thing to be done is to determine the specific conditions which nature has established, the principal items being average, maximum, and minimum rainfall, drainage area, run-off, evaporation, absorption, available head, flood, and minimum discharge of the stream.

There are two factors which enter directly into the determination of a water power: the quantity of water flowing down a stream per unit of time, and the "fall" or "head" available. The fall or head should be determined by a competent surveyor. This head is usually limited by the cost of the overflowed lands. It is advisable to accompany the surveyor when he runs his levels, in order to see that no little drainage ditches or natural outlets are overlooked which might be draining many acres of valuable land and which would be rendered useless when the water is backed up by the dam. A county map is a great aid in getting the acreage of the submerged lands.

The next quantity to be determined is the quantity of water flowing in the stream per unit of time. It is usual practice to get this in terms of pounds per minute. This determination is extremely important and to be accurate the measurements should extend over a period of several years. This usually being impossible, the best that can be done will be to take measurements at periods of low water. If the observer is a stranger in the community, good information as to these periods of low water may be obtained from some of the old fishermen or hunters. It is not advisable to depend on the merchants or bankers for this information. If the stream is large enough a government report may be had by applying to the United States Geological Survey. These reports are very valuable in making an estimate of the annual power, but care should be taken in using the reports on maximum-flood flow, as in some instances they are unreliable.

The quantity of water flowing in a stream may be fairly well estimated as follows: The velocity of water is obtained by means of a float. In this method of measurement the velocity is obtained by observing the time it takes a light floating body, such as a ball or piece of wood, so colored and weighted as to be readily seen, to pass over a known distance. The surface velocity is then

$$v = l \div t,$$

where l is the distance described between parallel transverse alinements whose distance apart is known, and t = the time taken. The velocity is a maximum just below the surface and diminishes from that point both toward the bottom and toward the surface. It is also a maximum near the middle of the stream, diminishing toward the banks. The mean velocity is

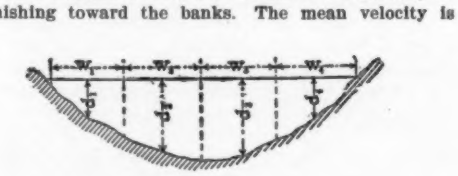


FIG. 1.

about 83 per cent of the maximum surface velocity when the air is still.

Therefore:

$$Q = 0.83\,A\,v, \qquad (1)$$

where

Q = discharge in cubic feet per second,

A = area of transverse section of the stream in square feet,

v = maximum surface velocity in feet per minute when the air is still.

Of eight experiments cited by Prof. Bowser, only one gives a value (= 0.62) differing more than 0.05 from 0.83, while others obtained the values 0.82, 0.78, 0.82, 0.86, 0.82, 0.83.

The horse-power available is obtained from the formula:

$$H.P. = \frac{(Q)\,(h)\,(62.5)}{33{,}000} \qquad (2)$$

where h = the fall or head, in feet.

An improvement over the foregoing is to divide the stream into a number of subdivisions (Fig. 1) in widths, w_1, w_2, w_3, etc, and mean depths of d_1, d_2, d_3, etc., and with respective maximum surface velocities of v_1, v_2, v_3, etc., which may be determined either with a float or with current meters; whence we may write:

$$Q = 0.83\,(w_1 d_1 v_1 + w_2 d_2 v_2 + w_3 d_3 v_3 +) \qquad (3)$$

The use of double floats (Fig. 2) is preferred by many engineers. Two balls of the same bulk and condition of surface, one lighter, the other heavier than water, are united by a slender chain, their weights being so adjusted that the light ball without projecting

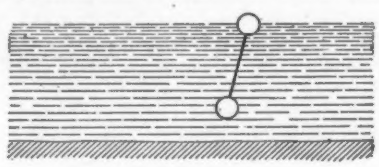


FIG. 2.

above the surface buoys the other ball at some predetermined depth. By placing several double floats across a stream and noting their velocity the average velocity may be quite accurately determined.

If a very accurate determination of the velocity is desired, a reliable current meter should be employed. There are three general methods for getting the velocity with a current meter; the single-point method, the multiple-point method and the integration method. In the single-point method the current meter is held at the depth of mean velocity, which is about 0.6 of the distance from the surface to the bottom. This method is used a great deal and is sometimes called the "six-tenths depth method." In what is known as the single-point subsurface method the current meter is held near the surface or just low enough not to be affected by the wind. This method is used when the meter cannot be submerged to 0.6 of the depth on account of the swiftness of the stream.

The multiple-point method may be subdivided into (1) the vertical-velocity curve; (2) surface and bottom, and (3) surface, mid-depth, and bottom. The vertical-velocity curve method consists of taking velocities at several depths equal intervals apart and taking the mean velocity of the stream at the average of these values. The surface and bottom method is sometimes used for shallow streams with comparatively smooth beds. The current meter is held about six inches below the surface and about six inches above the bottom, and the mean of the two velocities is taken as the average velocity of the stream. In the top, mid-depth and bottom method the current meter is held six inches below the surface, at mid-depth and six inches above the bottom. The mean velocity is obtained by dividing the sum of the top velocity, twice the mid-depth velocity and the bottom velocity by four. In the integration method the meter is lowered to the bottom at a slow uniform speed, then back again to the surface. The total number of revolutions divided by the time gives the mean velocity. It is well adapted for measurements under ice and as a check on the point methods.

In small streams the quantity of water may be measured by means of a weir. From extensive experiments at Lowell, Mass., with rectangular overfall weirs, J. B. Francis deduced the following formula:

$$Q = 3.33\,(L - 0.1\,n\,H)\,H$$

where

Q = discharge in cubic feet per second,

L = length of weir in feet,

H = distance in feet from sill of notch to level surface of water a few feet back,

n = number of contractions.

In general:

$n = 2$ when no edge is flush with the sides or bottom of a channel (Fig. 3),

$n = 1$ when one end only is flush with the side of the channel,

$n = 0$ when both sides are flush with the sides of the channel.

The foregoing values of n apply only when the sectional area of stream is very large compared with the area ($L\,H$) of the weir. If L is greater than 10 H the effect of end contraction may be neglected without appreciably affecting the result; L should be equal to or greater than 3 H and p should be equal to or greater than 2 H.

Ice formation has considerable effect on the flow of streams, hence due allowance must be made for it. It diminishes the cross-section of the stream and reduces the velocity of the water. Some of the rivers in the northern States have as low an efficiency as 50 per cent in winter, due to ice formation. In very shallow, broad streams with rough bottoms the loss is very large. Due allowance must be made for both the decrease of the transverse section of the stream and the reduction of the velocity of flow.

The question of a good reservoir is a very important one in determining the value of a water power. The use to which the power is to be or may be put should be known. The size of the reservoir depends very much on the value of the land and in cold climates due allowances must be made for ice. In climates where the ice freezes several feet thick, the depth of the reservoir would have to be increased considerably. The following example illustrates the importance of reservoirs:

A certain stream has an available head of 24 feet and a flow of 6,000 cubic feet of water per minute, thus giving 272 available horse-power. A town on the river requires 500 horse-power for four hours a day for lighting purposes. The power is not sufficient. A reservoir might be put in to store water for the remaining twenty hours. The storage area would be

$$\frac{(6{,}000)\,(20)\,(60)}{43{,}560} = 162$$

acres, if the reservoir is one foot deep. The total energy stored would be

$$\frac{(6{,}000)\,(24)\,(20)\,(62.5)}{33{,}000} = 5{,}500$$

horse-power-hours, giving

$$5{,}500 \div 4 = 1{,}375$$

horse-power for four hours, which is ample for the town. The energy required by the town at ten cents per kilowatt-hour is worth $54,000 a year. The total gross earnings is usually the principal factor which determines whether a reservoir may be used to advantage.

BOTTLES BY MACHINERY.

THE bottle-making machine was born of necessity. A French glass manufacturer was harassed by labor troubles in one way or another until at last he shut down his plant. Then he set to work trying to devise a machine that would take the place of men in blowing bottles. It was not many months before machines were installed, and his work started again. This was the forerunner of the American machine that is so nearly human that it can do its work better than men, and can make bottles for 40 cents a hundred which cost 70 cents under the hand method.

The making of bottles was long believed to be the one branch of glass making that hand laborers could depend upon as being free from machine competition. The introduction of the bottle-making machinery exploded that theory, and when the manufacturer recites

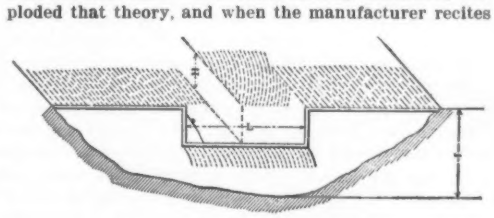


FIG. 3.

the advantages of the machine-made bottle over the hand-made, and adds that the number of bottles broken among hand-made ones was 30 per thousand, as compared with 3 per thousand, machine-made, he clinches his argument against the older method.

One of the boons of the new method is the fact that pulmonary diseases, which were very frequent among bottle-blowers, have been almost entirely overcome by the new method. Passing the blowing tube from lip to lip spread contagion, and the high death rate among glass blowers was attributed more to this than any one cause. In the machines compressed air does the work that was hitherto required of human lungs, and the sick and death rates have both fallen off since the introduction of the machines. More than 25 factories are now turning out machine-made bottles.—The Spatula.

GASOLINE AND ALCOHOL ENGINES.*

COMMERCIAL DEDUCTIONS FROM COMPARISON TESTS.

BY ROBERT M. STRONG.

Continued from Supplement No. 1773, page 403.

SYNOPSIS OF RESULTS AND GENERAL CONCLUSIONS.

SOME of the more important results and conclusions stated in this bulletin are summarized below:

1. The low heating value of completely denatured alcohol will average 10,500 British thermal units per pound, or 71,900 British thermal units per gallon.

The low heating value of 0.71 to 0.73 specific gravity gasoline will average 19,200 British thermal units per pound, or 115,800 British thermal units per gallon.

The low heating value of a pound of alcohol is approximately six-tenths of the low heating value of a pound of gasoline.

A pound of gasoline requires approximately twice the weight of air for complete combustion as a pound of alcohol.

The heating value of a cubic foot of an explosive mixture of alcohol vapor and air having theoretically just sufficient air for complete combustion is approximately equal to that of a cubic foot of a similar explosive mixture of gasoline vapor and air—about 80 British thermal units per cubic foot.

2. Explosive mixtures of alcohol vapor and air can be compressed to much higher pressures in an engine cylinder without preigniting than can explosive mixtures of gasoline vapor and air. The maximum pressure of compression that can be used without causing preignition will in each case depend partly on the quality of the explosive mixture, on the design of the engine, and the speed at which it is operated.

For 10 to 15-horse-power four-cycle stationary engines of the usual type a compression pressure of about 70 pounds per square inch above atmospheric was found to be the maximum that could be used for gasoline mixtures, and about 180 pounds the maximum that could be used for alcohol mixtures without causing preignition.

The maximum compression pressure that could be used without causing preignition was in each case found to be the most advantageous from the standpoint of fuel economy.

3. When the degree of compression is in each case that best suited to the economical use of the fuel designated, some types of gasoline engines are better adapted to the service for which they are designed than similar alcohol engines, and *vice versa*. The relative amount of fuel consumed being disregarded, this is also true when the degree of compression is that ordinarily used for gasoline mixtures, as when denatured alcohol is used in gasoline engines; but in general the alcohol engine is or can be so designed and constructed as to be equal to the gasoline engine in adaptability to service.

A gasoline engine having a compression pressure of 70 pounds but otherwise as well suited to the economical use of denatured alcohol as gasoline will, when using alcohol, have an available horse-power about 10 per cent greater than when using gasoline.

When the fuels for which they are designed are used to an equal advantage, the maximum available horse-power of an alcohol engine having a compression pressure of 180 pounds is about 30 per cent greater than that of a gasoline engine having a compression pressure of 70 pounds, but of the same size in respect to cylinder diameter, stroke, and speed.

When denatured alcohol is used in 10 to 15-horse-power four-cycle stationary engines having a compression pressure of approximately 180 pounds and the engines are operated at their maximum loads, the pressures during explosion or combustion reach 600 to 700 pounds. Stationary gasoline engines, in which the compression pressure in some cases can be raised to 180 pounds, are not usually built heavy enough to withstand such explosion pressures for any length of time.

4. A gasoline engine having the degree of compression ordinarily used for gasoline mixtures will in general require 50 per cent more denatured alcohol than gasoline per brake horse-power per hour.

Gasoline and alcohol engines of similar construction having degrees of compression best suited to the fuel supplied will in general require equal volumes of gasoline and denatured alcohol, respectively, per brake horse-power per hour.

Gasoline engines of the usual four-cycle stationary type will ordinarily consume about a pint of gasoline per brake horse-power per hour when operated at about rated load and with a reasonably favorable adjustment of the mixture quality and time of ignition.

When carrying light loads or carrying their maximum loads, gasoline and alcohol engines governed for constant speed require a greater quantity of fuel per brake horse-power per hour than when carrying their rated loads, if rated at about 75 to 80 per cent of their maximum loads; but unless the mixture quality and time of ignition are adjusted to suit each change of load, the rate of consumption per brake horse-power per hour will in general be least at maximum load and will increase with decrease in load.

When any of the usual methods of governing are used to control the speed of gasoline or alcohol engines, the rate of fuel consumption per brake horse-power per hour will ordinarily be about twice as great at one-third load as at maximum load. At the same time an excessive rate of consumption of gasoline or denatured alcohol at any given load, if due to the incorrect adjustment of the mixture quality and time of ignition only, may be as great as but not greater than approximately twice the minimum required before it will be noticeable from outward indications.

5. The thermal efficiency of alcohol and gasoline engines will in general increase with the pressure to which the charge is compressed when ignited.

The maximum thermal efficiency of 10 to 15-horse-power four-cycle stationary engines of the usual type when operated with a minimum amount of throttling was found to increase with the compression pressure according to the formulæ $E=1-\left(\frac{14.7}{P}\right)^{.17}$ for gasoline and $E=1-\left(\frac{14.7}{P}\right)^{.19}$ for alcohol, where $E=$ the thermal efficiency based on the indicated horse-power and low heating value of the fuel and $P=$ the indicated pressure of the charge at the end of the compression stroke in pounds per square inch absolute.

6. A high thermal efficiency and a rate of consumption of less than a pint per brake horse-power per hour, both for gasoline and for denatured alcohol, can often be obtained when the degree of compression, the load, the quality of the explosive mixture, and the time of ignition are carefully adjusted. A fair representation of the best economy values obtained, taken from the results of tests on 10 to 15 horse-power Nash and Otto stationary engines, and the corresponding thermal efficiencies are given in the following table:

Results from Tests Made on 10 to 15-Horse-Power Nash and Otto Stationary Engines.

Fuel.	Compression Pressure (Pounds).[1]	Fuel Consumed per Brake Horse-Power per Hour.		Thermal Efficiency (Per Cent).[2]
		Pound.	Gallon.	
Gasoline......	70	0.60	0.100	26
	90	0.58	0.097	28
Alcohol.......	70	0.96	0.140	28
	180	0.71	0.104	39
	200	0.68	0.099	40

[1] Per square inch above atmosphere.

[2] Based on the indicated horse-power and the lower heating value of the fuel.

7. When by means of a double carbureter gasoline and alcohol are used simultaneously in varying proportions from practically all gasoline to practically all alcohol, the most advantageous degree of compression will vary from that found to be the best for gasoline mixtures to that found to be the best for alcohol mixtures.

Tests that were made with such an adjustment of compression indicate that the total amount of fuel (gallons of gasoline + gallons of denatured alcohol) required for any given load is practically constant for the entire range of proportions from all gasoline to all denatured alcohol.

8. When water is sprayed into an explosive mixture of gasoline vapor and air as it is being taken into the cylinder of an engine and is introduced at the most advantageous location, it may in many cases be supplied in amounts up to as much water as gasoline by weight without affecting the performance of the engine, except as noted below.

The capacity or maximum available horse-power of an engine decreases with an increase in the percentage of water, by weight, present in the explosive mixture of gasoline vapor and air.

When used in an engine having a constant degree of compression, the presence of water in an explosive mixture of gasoline vapors and air in quantities equal to or less than the weight of gasoline does not increase or decrease the amount of gasoline required to carry any given percentage of the corresponding maximum available load.

The pressure to which an explosive mixture of gasoline vapor, water, and air can be compressed in an engine cylinder without preigniting increases with an increase in the percentage of water in the mixture, and can be raised to about 140 pounds when the weights of water and gasoline are equal.

That the amount of gasoline required is not affected by an increase in the compression pressure when preignition is prevented only by the introduction of water as above stated is indicated by the results of tests made on an engine having a compression pressure of 130 pounds. These tests are limited, however, and the results are not conclusive.

9. Alcohol diluted with water in any proportion from denatured alcohol, which contains about 10 per cent of water, to mixtures containing about as much water as denatured alcohol can be used in gasoline and alcohol engines if they are properly equipped and adjusted.

When used in an engine having a constant degree of compression, the amount of pure alcohol required for any given load increases and the maximum available horse-power of the engine decreases with a diminution in the percentage of pure alcohol in the diluted alcohol supplied. The rate of increase and decrease respectively is such, however, that the use of 80 per cent alcohol instead of 90 per cent, or denatured alcohol, has but little effect on the performance of the engine; so that if 80 per cent alcohol can be had for 15 per cent less cost than 90 per cent alcohol and could be sold without tax when denatured, it would be more economical to use the 80 per cent alcohol.

When an engine is supplied with diluted alcohol, the compression pressure that can be used without causing preignition increases with an increase in the percentage of water by weight in the mixture, but no tests were made to determine the effect of increased compression pressure on the economy with which diluted denatured alcohol could be used.

10. The relative hazard involved in the storage and handling of gasoline and denatured alcohol is of particular importance in considering their use as fuels for marine and factory engines to be placed in the basements of office buildings, in coast-defense fortifications, or in like places where a general fire would be likely to result from the accidental burning of the fuel stored or carried for immediate supply, or where the forming of explosive or inflammable mixtures of the fuel vapors and air in the immediate vicinity would be hazardous.

It is indicated by statistics and is also the consensus of opinion of those experienced in handling gasoline, kerosene, and alcohol that the hazard involved in the use of denatured alcohol is very much less than in the use of gasoline and possibly less than in the use of kerosene, but as yet the relative fire risk has not been definitely established. Considerable work has been done on this phase of the investigation, and a series of tests that will be of assistance in determining the relative hazard involved in the use of these fuels is in progress at the testing station of the United States Geological Survey in Pittsburg, Pa.

11. In regard to general cleanliness, such as absence of smoke and disagreeable odors, alcohol has many advantages over gasoline or kerosene as a fuel. The exhaust from an alcohol engine is never clouded with a black or grayish smoke, as is the exhaust of a gasoline or kerosene engine when the combustion of the fuel is incomplete, and it is seldom, if ever, clouded with a bluish smoke when a cylinder oil of too low a fire test is used or an excessive amount supplied, as is so often the case with a gasoline engine. The odors of denatured alcohol and the exhaust gases from an alcohol engine are also not likely to be as obnoxious as the odor of gasoline and its products of combustion.

12. Very few alcohol engines are being used in the United States at the present time, and but little has been done toward making them as adaptable as gasoline engines to the requirements of the various classes of service. Engines for stationary, marine, and traction service, automobiles, motor trucks, and motor railway cars designed especially to use denatured alcohol have, however, been tried with considerable success.

The price of denatured alcohol is greater than the price of gasoline, and the quantity of denatured alcohol consumed by an alcohol engine as ordinarily constructed and operated is in general relatively greater than the quantity of gasoline consumed by a gasoline engine of the same type. Considerable attention is be-

* Bulletin published by United States Geological Survey.

ing given to the development of processes for the manufacture of alcohol from cheap raw materials which are generally available, and it seems reasonable to expect that the price of denatured alcohol will eventually become as low as or lower than the price of gasoline, especially if the price of gasoline advances. It also seems reasonable to expect a greater general improvement in alcohol engines than in gasoline engines.

When used as a fuel, denatured alcohol is not always so classed as to be exempt from restrictions placed on the use of gasoline by the rules of insurance and transportation companies or city ordinances. The restrictions that are placed on the use of denatured alcohol are, however, never greater than those placed on the use of gasoline. In some places they are such that the use of an alcohol engine is permitted where the use of a gasoline engine is prohibited. For instance, alcohol motor trucks and automobiles are admitted to many of the steamer piers in New York that are not open to gasoline machines.

Where the restrictions placed on the use of denatured alcohol are less than those placed on the use of gasoline or where safety and cleanliness are important requisites, the advantages to be gained by the use of alcohol engines in place of gasoline engines may be such as to overbalance a considerable increase in the fuel expense, especially if the cost of fuel is but a small portion of the total expense involved, as is often the case. Denatured alcohol, will, however, probably not be used for power purposes to any great extent until its price and the price of gasoline become equal and the equality of gasoline and alcohol engines in respect to adaptability to service required and quantity of fuel consumed per brake horse-power, which has been demonstrated to be possible, becomes more generally realized.

A further general development in the design and construction of engines that use kerosene, or cheaper distillates, and the crude petroleums may be reasonably expected and may delay the extensive use of denatured alcohol for some time to come, but as yet comparatively few data pertaining to this phase of the general investigation are available. Some investigations relating specifically to the extent and economy with which these cheaper oils can be used as fuels for internal-combustion engines of the types suited to various classes of service are, however, in progress at the testing station of the United States Geological Survey, where a Hornsby-Akroyd and a Mietz & Weiss oil engine have been installed.

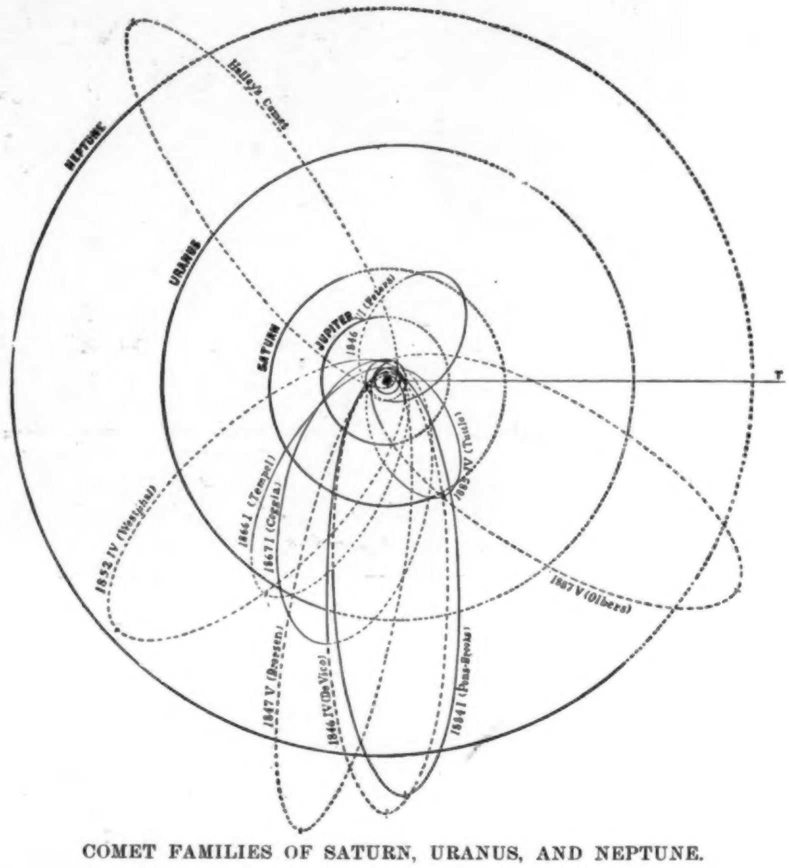
CAPTURED COMETS.*

THE FAMILIES OF SATURN, URANUS, AND NEPTUNE.

BY H. C. WILSON.

In vol. vi. of Popular Astronomy Plate I is a diagram of the comet families of the planets Saturn, Uranus, and Neptune, drawn by Dr. A. G. Sivaslian, of Anatolia College, Marsovan, Turkey. One of our readers has recently called attention to a technical error in this plate and suggested that the diagram be revised and brought up to date. This we have attempted to do and the results are herewith presented.

The error referred to is a technical one resulting from neglecting the inclinations of all the comet orbits to the plane of the ecliptic and drawing, not their projections upon that plane, but their true forms as if they all lay in that plane, indicating by dotted lines the portions of the curves which lie below the ecliptic. In the case of the Jupiter family of comets the inclinations are in general so small that the diagram constructed in this way gives very nearly the true projection of the family of orbits. In the case of these outer families the inclinations average much higher, so that a true projection would not give at all the true forms of their orbits. For example, the orbit of the Pons-Brooks comet is inclined 74 deg. to the plane of the ecliptic. The line of nodes or intersection of the plane of the orbit with the plane of the ecliptic makes an angle of 254 deg. with the line from the sun to the vernal equinox. In order to get the true perspective of the orbit one must imagine the right side of the ellipse to be lifted up from the paper and tipped over toward the left, the dotted portion being tipped downward and to the right, so that the projection will appear much narrower than the true orbit and will lie almost wholly within the projection of the orbit of Brorsen's comet. The orbit of DeVico's comet likewise must be tipped over through an angle of 85 deg, so that it will be almost perpendicular to the plane of the ecliptic, and will also lie almost wholly within the projection of the orbit of Brorsen's comet.



COMET FAMILIES OF SATURN, URANUS, AND NEPTUNE.

The orbit of Halley's comet has an inclination of 162 deg, and the longitude of the ascending node is 57 deg. The inclination is so great that the orbit must be tipped clear over to within 18 deg. of the ecliptic on the other side, so that as projected its motion is backward (retrograde) and the aphelion point is in longitude 125 deg. approximately, instead of 345 deg., as shown on Plate I, vol. vi., where the effect of the inclination was neglected.

* Popular Astronomy.

Tempel's comet (1866 I) also has an inclination of more than 90 deg. so that its motion is retrograde. Its line of nodes lies more nearly lengthwise of the orbit than does that of Halley's comet, so that the change of position of the orbit when correctly projected is not so marked as in the case of the latter comet.

TABLE I.

ELEMENTS OF THE SATURN, URANUS AND NEPTUNE FAMILIES OF PERIODIC COMETS

Name	Period in Years	Time of Perihelion Passage Greenwich M. T.	Perihelion Distance	Aphelion Distance	e	ω	Ω	i	Mean Equinox	Calculator and Reference
						° ′ ″	° ′ ″	° ′ ″		
1846 VI (Peters)	13.376	1846 June 1.134	1.52928	9.7404	0.728605	339 37 44	260 23 53	30 40 10	1846.0	Berberich, *A. N.* CXVII, 251
Tuttle	13.667	1899 May 4.515	1.01913	10.4133	0.821712	206 39 09	269 49 54	54 29 16	1900,0	Rahts *A. N.* CXLIX, 42
1866 I (Tempel)	33.2	1866 Jan. 11.134	0.97652	19.6747	0.905421	170 57 13	231 52 59	162 41 57	1899.0	Bidschof, *A. N.* CXLIV, 299
1867 I (Coggia)	40.1	1867 Jan. 20 207	1.57723	21.3502	0.855352	357 31 15	78 27 35	18 12 33	1867.0	Becker, *M. N.* LI, 489
1852 IV (Westphal)	60.66	1852 Oct. 12.751	1.24996	29.6262	0.919034	57 08 42	346 10 00	40 55 00	1852.0	Westphal, *A. N.* L, 49
Pons-Brooks	71.56	1884 Jan. 25.717	0.77573	33.6980	0.954996	199 11 33	254 05 42	74 02 36	1880.0	Schulhof-Bossert, *A. N.* CVIII, 16
Olbers	72.65	1887 Oct. 8.479	1.19912	33.6234	0.931130	65 20 11	84 32 20	44 34 16	1890.0	Ginzel, Rechen-Inst-Publ. 3, p. 33
1846 IV (DeVico)	75.71	1846 Mar. 5.546	0.66380	35.1301	0.962910	12 58 26	77 33 16	85 06 27	1846.0	Heppberger, *A. N.* CXVII, 245
Halley	76.0	1910 Apr. 19.65	0.58715	35.3034	0.967281	111 42 16	57 16 12	162 12 42	1910.0	Cowell and Crommelin, *M. N.* LXVIII, 393. The Observatory Oct. and Nov., 1909
1847 V (Brorsen)	81	1847 Sept. 9.516	0.48827	36.9700	0.973930	128 18 05	309 50 23	19 09 00	1847.0	Gould, *A. J.* I, 143

In the diagram Plate X we have given the true forms of all the orbits neglecting the inclinations except that in the case of Halley's and Temple's comets the orbits have been plotted to correspond to retrograde motion.

In the diagram, Fig. 1, the true projections of all the orbits have been drawn to the same scale as on Plate X. A glance at these diagrams shows at once the very marked change in position of the orbits of the Olbers, Pons-Brooks, DeVico, and Westphal comets when they are correctly projected. The paths of the Olbers and Westphal comets no longer reach out to the orbit of Neptune, and they should probably not be classified as belonging to the Neptune family. The fact that their descending nodes are near the orbit of Jupiter would rather point to their being members of the Jupiter family.

If, however, we take the position of the nodes as a criterion none of the six comets which have been reckoned in the Neptune group really belong there. Halley's and Brorsen's have their nodes near the paths of earth and Mars; DeVico's and Pons-Brooks's belong to the Uranus group with Tempel's and Coggia's. None of these comets in their present orbits can approach near enough to Neptune to have their orbits very seriously disturbed by that planet.

Of the two comets in the Saturn group, Peters's has its descending node near the path of Saturn, but the nearer node of Tuttle's comet is farther from Saturn's than it is from Jupiter's orbit, and it may be questionable to which planet the latter comet belongs.

The elements which were employed in making the diagrams are given in Table I, together with a refer-

ence giving the authority for each. In every case we have selected what seemed to us to be the most reliable elements which have been published. Those of Halley's comet are being revised by the aid of recent observations and so will be subject to slight changes, but the time of perihelion passage is now known within a small fraction of a day and the other elements cannot change very much.

Of the ten comets four only have been observed at more than one apparition; Tuttle's has been seen at five apparitions, Pons-Brooks's and Olbers's each at two, and Halley's at no less than twelve successive apparitions. Peters's 1846 VI. must be considered as a lost comet since it has not been detected at any of its four returns since 1846. If its period is unchanged, it is due again in 1913. Tuttle's and Westphal's comets are also due in 1913, DeVico's should return about 1921, Brorsen's about 1928, Tempel's in 1932, Olbers's about 1960. Coggia's was due somewhere from 1905 to 1909, but has not been detected, the period being uncertain by two or more years. Halley's has recently come into sight on its return for 1910 but will not be visible to the naked eye until some time in next April or May.

ACHIEVEMENT IN POLAR EXPLORATION.*

THE EXHIBIT OF THE PEARY ARCTIC CLUB.

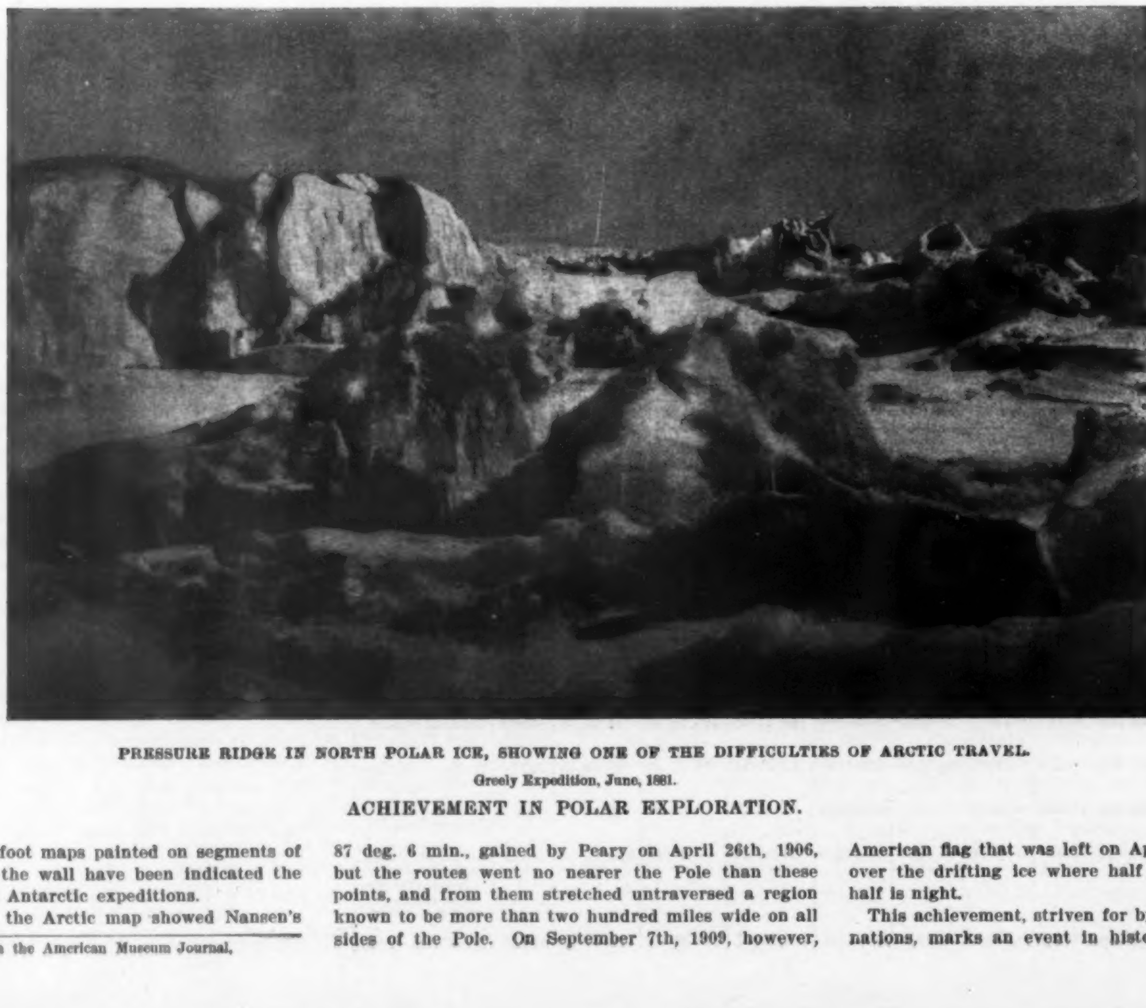
For several years a record of polar exploration has been on exhibition at the Museum of Natural History in the east corridor immediately off the main foyer. Here, on two fifteen-foot maps painted on segments of a globe fastened to the wall have been indicated the routes of Arctic and Antarctic expeditions.

On September 6th the Arctic map showed Nansen's farthest north, 86 deg. 14 min., reached in 1895, the Duke of the Abruzzi's (Cagni's) record, 86 deg. 33 min., made in 1900, and the northernmost point of all, 87 deg. 6 min., gained by Peary on April 26th, 1906, but the routes went no nearer the Pole than these points, and from them stretched untraversed a region known to be more than two hundred miles wide on all sides of the Pole. On September 7th, 1909, however, the red cord marking Peary's latest expedition spanned this remaining distance, and a small flag floated at the center of the Arctic map to bear record to the larger American flag that was left on April 6th, 1909, waving over the drifting ice where half the year is day and half is night.

This achievement, striven for by many men of many nations, marks an event in history. It closes a cen-

THE PEARY ARCTIC CLUB EXHIBIT.

A great map painted on the floor shows Peary's route to the North Pole.



PRESSURE RIDGE IN NORTH POLAR ICE, SHOWING ONE OF THE DIFFICULTIES OF ARCTIC TRAVEL.

Greely Expedition, June, 1881.

ACHIEVEMENT IN POLAR EXPLORATION.

* Reprinted from the American Museum Journal.

tury of Arctic research, which century in turn was the culmination of a period of three centuries of exploration, if we count the exploits of whaling and sealing vessels and the early expeditions in search of a short water route from western Europe to the Orient. Some facts have been discovered, some things proved not true, and the field is clear for new achievement along other lines, to the end that man may have a fairer understanding of the universe in which he finds himself.

On the morning of October 12th, an exhibition by the Peary Arctic Club was opened in the west wing of the Museum. The presentation in this exhibit is unusually vivid. A half hour in the hall leaves one imbued with the feeling that he has actually traveled into the untenanted world around the North Pole. In the first place the exhibit is installed to give an effect of simplicity and severity, of much uninterrupted space, cold white surroundings and few objects. Those in charge were careful not to draw on the Museum's well-filled storehouses of Arctic materials to such an extent as to destroy this atmosphere of severity. In the second place, because of the nature of the exhibit, everything speaks of adventure, of a difficult life, often of narrow escape, and sometimes of disaster. This is true throughout, from the relic of the wrecked "Polaris"—a battered life boat that acts as a signboard just outside the entrance of the hall, to the view of the "Polaris" in Thank God Harbor—an immense canvas at the far end. Every object in the place seems to take on life as a representative of the daring work of some explorer.

In imagination we see the sleeping bags, displayed near the entrance, with their voluminous fur folds wrapped about the traveler shutting out the savage cold. We see the sledges not as mere dead frameworks of wood, but as active aids to man. In our awakened fancy, they have iced runners and, loaded with provisions, they cut deep trails as with dogs and drivers they pass always on into boundless ice and snow.

The mounted dog, placed here to illustrate the Eskimo method of harnessing, brings to mind the long double-ranked teams, or the fan-shaped teams of eight as Peary drove them, dragging their burdened sledges, obeying word and whip day after day until too weak to help the expedition longer, except by giving their bodies as food to strengthen their fellows; while those who have read "Northward Over the Great Ice" recall Peary's tribute to the dogs of that journey: "Faithful, noble servitors. . . . My only consolation is the knowledge that like ourselves you did not suffer pain. The starvation was so gradual that when at last your lives went out . . . the end was painless, as our own would have been had it not been for you." The mounted musk oxen, the many shaggy brown pelts wound about the pillars and the numerous skulls piled upon the floor, bring to mind forcefully the dependence of the explorer upon these animals for food. We get a more vivid understanding of the eagerness with which he has many a time searched the ground for musk ox tracks, and a more keen sympathy with his fear when he saw one or more of the great creatures, that his eyes blinded by the incessant glare of the ice would give a false aim at the critical moment.

The realism of the exhibit is increased by the work of a newly-invented automatic stereopticon placed in a darkened alcove at the right of the hall. Through its display of pictures (uninterrupted from nine in the morning until five in the afternoon) the visitor is carried into the heart of the Arctics. He looks on boats and men, sledges and dogs, in action; he sees in these pictures the very mountains and icebergs, the selfsame pressure ridges or "rafters" of ice and the leads of open water that the explorer saw in reality.

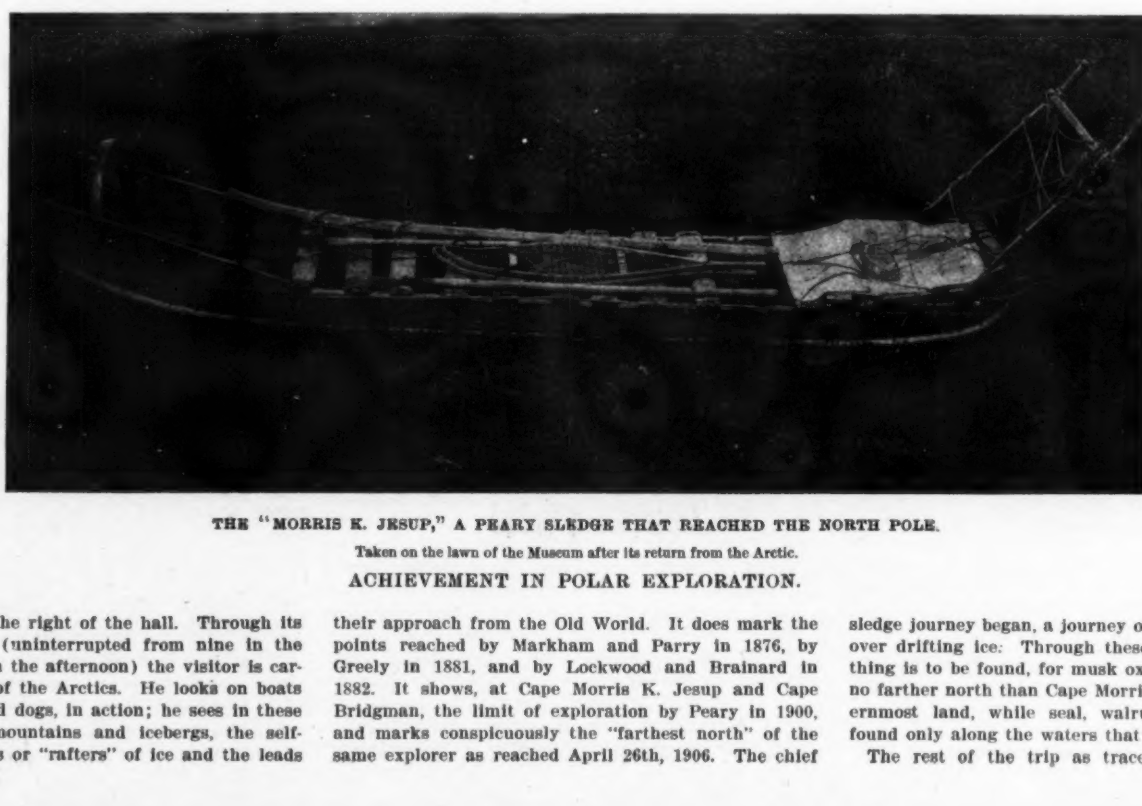
The central and most striking feature of the hall is a map painted in color on the floor over a space 30 feet by 50 feet in dimensions. It presents the approach to the Pole from North America only, the more frequently used of the two principal paths of exploration, namely: the route between Nova Zembla and Franz Josef Island, the direct course from Europe; and that through Davis Strait, Baffin Bay, and Smith Sound, a lane of open water stretching northward between Gerenland on the east and the line of Arctic American islands extending from Labrador to Ellesmere Land on the west. This map, therefore, does not show the route of Nansen, nor does it give that of the Duke of the Abruzzi, since both of these men made their approach from the Old World. It does mark the points reached by Markham and Parry in 1876, by Greely in 1881, and by Lockwood and Brainard in 1882. It shows, at Cape Morris K. Jesup and Cape Bridgman, the limit of exploration by Peary in 1900, and marks conspicuously the "farthest north" of the same explorer as reached April 26th, 1906. The chief aim of the map, however, is to show the route of Peary's last or eighth expedition, financed by the Peary Arctic Club.

The story graphically spread out on the floor concerns more than a year's time and a distance of 800 geographical miles from Cape York northward to the Pole. The expedition started from Cape York August 1st, traveling up Smith Sound. It reached Cape Alexander August 18th, and Fort Conger September 2nd, the latter place being about 500 miles distant from the Pole. At Cape Sheridan the "Roosevelt" remained in winter quarters, as is indicated by the presence of a small model of the boat placed on the map at this point. On March 1st, a few days before the sun rose above the horizon after the long Arctic night, the sledge journey began, a journey of more than 400 miles over drifting ice. Through these 400 miles no living thing is to be found, for musk oxen and caribou range no farther north than Cape Morris K. Jesup, the northernmost land, while seal, walrus, and narwhal are found only along the waters that margin the land.

The rest of the trip as traced shows a veritable

AN EXPLORER'S TRAIL LEFT AT THE ICE FOOT ON THE COAST OF GRINNELL LAND.

Greely Expedition, May, 1882.



THE "MORRIS K. JESUP," A PEARY SLEDGE THAT REACHED THE NORTH POLE.

Taken on the lawn of the Museum after its return from the Arctic.

"dash to the Pole." On March 11th, 84 deg. north was passed, and a week later, 85 deg. north was reached, 300 miles from the Pole. By March 27th the expedition passed 87 deg. north, and April 2nd, 88 deg. north, only 120 miles from the Pole and farther north than any human being had ever before penetrated. Only four days later camp was made at the journey's end, and the American flag was flying at 90 deg. north.

There is scarcely anything in the Peary Arctic Club's exhibit outside of this map that attracts more attention than a sledge on the west side of the hall among piles of musk ox, caribou, and walrus hides, crates of skulls and antlers, and the many other things that the "Roosevelt" brought south with her stowed away in every available place, even drying in the rigging. Though only a sledge, it seems deserving honor, for it bears this legend: "A sledge that reached the Pole." In reality, success has come to polar exploration through use of the sledge as a means of travel.

Before 1820 ships alone were used. When frozen in, an expedition was delayed until a time of thaw. It was not until the second or third voyage of Parry and the second of Sir John Ross, that is, in 1821 and 1834, that sledging expeditions began and the fact was discovered that "ice which arrests the progress of the ship forms the highway for the sledge." Since that time there has been great advance in sledge construction, in the light of which fact it is interesting to compare the sledges in the possession of the Museum. This sledge that reached the Pole is 12 feet long and 2 feet wide. It consists of two wooden runners curved upward at both ends and wooden slats crossing the runners several inches apart and bound loosely to them by thongs of walrus hide. Light and flexible, it is able to rise and dip through the snow of steep descents without the slightest injury to itself, and has surely proved its fitness for Arctic travel.

The exhibit is instructive as to the manner of maintaining life in the difficult environment of the Arctics. A case is filled with the skins and tools used in igloo building, another contains kayaks, harpoons, and various fishing and hunting paraphernalia. From the facts brought out here, we learn the total dependence of the Eskimo on the few animals of the region, particularly the walrus and the seal. Still other cases contain garments of fur—fur of fox, seal, and reindeer. They show also coats made by fastening together many small bird skins.

There is much suggested also in the matter of Arctic travel aside from what has already been noted. One case contains the instruments used in exploration, such as sextant, chronometer, and compass, and beside these which tell of the success of science in invention and of exploration in making use of this invention are dramatically placed various crude implements and vessels fashioned by the Eskimo from copper taken from the wreck of Sir John Franklin's ship. An arching label, "A Century of Arctic Exploration," calls attention to still other cases containing the many books descriptive of expeditions to the Arctics. These books lie open at their title pages and, covering the time from the work of Sir John Ross to the present, invite further investigation.

As a whole, the exhibit has a note of triumph in it. There is triumph in the discoveries to science of lands and waters, in the improvement in life for the Eskimo through the intervention of civilized man, in the final direct route that Peary made, and the American flag floating above "the top of the world," in the map on the floor. The visitor reads also a greater triumph than these, for one who has heard accounts from lips of northern explorers or has felt a choking in the throat over the experiences recorded in some of the vivid writings of these same men, realizes the hardship involved in polar exploration, the years of privation and physical distress, of sacrific of all that to ordinary mortals makes life worth living. He knows that there has been set before the world an example of what above most things makes life worth living—the indomitable courage and perseverance that ends in accomplishment.

A MUSK OX AND A POLAR BEAR.
Peary Arctic Club Exhibit.

PART OF THE NORTH POLAR REGIONS, SHOWING LINES OF APPROACH FROM AMERICA AND EUROPE.

ACHIEVEMENT IN POLAR EXPLORATION

A NEW MAP OF THE WORLD.

Under the presidency of Col. S. C. N. Grant, R. E., Director-General of the Ordnance Survey, as chairman, a congress has just been opened at the Foreign Office of delegates of the British and certain foreign governments to consider the possibility and expediency of making a fresh map of the world. The proposed scale is 1 : 1,000,000, or nearly 16 miles to 1 inch. It is hoped to arrive at some unform set of symbols and conventional signs for adoption by all nations. Some recommendations formulated by the committee constituted in London in 1895 are advocated in the name of the International Congress. They comprise (*a*) polyconic projection upon each sheet independently on the middle meridian, the limiting meridians being scribed at intervals of 6 deg. reckoned from the meridian of Greenwich and the limiting parallels at intervals of 4 deg. from the equator, and each sheet showing an area of 4 deg. in latitude and 6 deg. in longitude; (*b*) a kilometer scale, with a scale in miles, if desired, on each sheet; (*c*) brown contour lines, complemented, it may be, with color tints, at vertical intervals of 200 meters, or multiples or parts of 200 meters, from sea level; (*d*) the distinguishing of roads and tracts suitable for vehicles from those which are not suitable; and (*e*) Latin characters for the lettering, and in different forms for natural and artificial features, but to meet cases in which Latin letters are not used the sheets to be produced in two editions for national and international purposes.—The Builder.

To determine concrete proportions for greatest density a writer suggests experiments with a receptacle holding 4 cubic feet, as, for example, a 15-inch sewer pipe. By using two or three sizes of crushed stone properly proportioned a denser concrete may be obtained, and cement and sand saved. If there are two sizes of stone, one passing a 1½-inch and the other a ¾-inch ring, the latter should be screened to remove all that will pass a ¼-inch screen, regarding this as sand. Then 2 cubic feet of the smaller and 2 cubic feet of the larger stone are well mixed and put into the pipe, and the top of the mixture marked on the side. A mixture of 2½ cubic feet of the larger stone and 1½ cubic feet of the smaller stone, and a number of other proportions are then tried, and the one giving the least volume will give the densest and strongest concrete with the least sand and cement.

USES OF BAKELITE.*

ITS ELECTRICAL AND ELECTROCHEMICAL APPLICATION.

BY L. H. BAEKELAND, SC.D.

IN my first paper on Bakelite read before the American Chemical Society,† I have set forth the theoretical reasons why we may consider Bakelite C, or the final product, as a polymerized compound anhydride of a phenol-alcohol and methylenglycol.

I have explained then and there how I have succeeded in producing this compound through indirect synthesis by the action of oxybenzyl alcohol on formaldehyde as well as by direct action of phenols on formaldehyde. The latter method is the more available one for practical purposes, and consists in heating under proper conditions, a mixture of phenols and formaldehyde in presence of a catalytic agent, preferably small amounts of bases or alkaline substances. According to the conditions of operating, I have succeeded in carrying out the process in three phases, designated as A, B, and C.

A is the "initial product of condensation" produced by elimination of water, and contains probably one or more hydroxyl groups in its molecule.

B is the so-called "intermediate condensation product," a higher anhydride evolved by further elimination of water. In the case of ordinary phenol, we then have oxybenayl-methylenglycol anhydride, the formula of which may be represented as

$$\overbrace{\qquad\qquad O \qquad\qquad CH_2 \qquad\qquad O \qquad\qquad}$$
$$CH_2-C_6H_4-O-CH_2-C_6H_4-O-CH_2-C_6H_4-O-CH_2$$
$$-C_6H_4-O-CH_2-C_6H_4-O-CH_2-C_6H_4$$

C is the polymer of B and can be represented by:

$$n(C_{42}H_{36}O_7)$$

or its homologs in case the other members of the phenol series be used.

It is the final condition in the bakelite process. This product C is characterized by the following properties:

It is a hard, structureless mass, which may be prepared in transparent or in opaque condition; its color varies from that of colorless glass to amber color or dark ruby or brown. It is harder than shellac, hard rubber, or celluloid, but misses the flexibility of the two latter substances and this is its main defect. On the other hand it withstands all solvents and most chemicals, resists boiling water, steam and superheated steam, and oils. Heating does not melt it, nor even soften it to any serious extent. Boiling concentrated sulphuric acid destroys it; so does concentrated nitric acid, but it withstands dilute sulphuric acid, hydrochloric acid, and chlorine. It can stand temperature of 300 deg. C. and over. At the temperature of melting glass it chars and carbonizes without entering into fusion. In its final condition it can be sawed, cut, bored, and turned on the lathe, but it can no longer be molded for practical purposes. In other words, when it has acquired condition C it is no longer a true plastic, so that all operations of molding or shaping must preferably be carried out in its earlier stages. In its final stage it is tasteless and odorless and an excellent insulator of heat and electricity.

In cost of production it can very advantageously compete with any known plastic.

For all practical purposes we use A as raw material to start with. The latter is obtained in four varieties, each of which may be preferable according to the special purpose in view.

Extra thin liquid A is a thin liquid of great penetrating power, and therefore is best fit for impregnating such bodies which absorb liquids with some difficulty, as, for instance, wood.

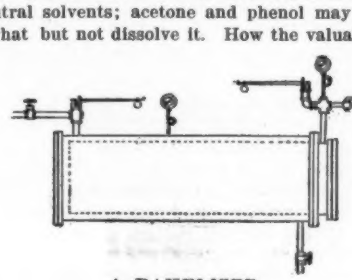
Liquid A is another variety of which the consistency is about that of molasses syrup. It can be made considerably thinner by slight heating. Longer heating at 60 deg. to 70 deg. C. thickens it gradually so that it can become pasty; still longer heating at this temperature may convert it into B, which is no longer fusible, but still remains soft while hot.

Dissolved A is a mixture of A with a small amount of alcohol which can be further diluted to proper strength by the proper addition of alcohol. If an excess of alcohol be added to it, the whole dissolved mass may reprecipitate and separate itself in two layers; a lower viscous one, containing the precipitated A, and a supernatant thin liquid containing mainly the added alcohol. Acetone redissolves this precipitate. The alcoholic solution dries in about the same way as shellac varnish, but drying at ordinary temperatures or even somewhat higher temperatures, does not bring the layer beyond the stage A; in other words, this varnish layer remains fusible and soluble. Only at relatively high temperatures and in presence of suitable amounts of catalytic agents does it transform finally in hard, soluble C. In all cases where the coating is rather thick or where it is applied on porous surfaces like wood, it becomes absolutely essential to carry out the heating in a bakelizer under suitable pressure, as explained below, so as to avoid air bubbles and blistering.

Solid A. A brittle, irregular, opaque, translucent, or transparent mass of about the consistency and brittleness of ordinary rosin or colophonium. It can be made in different degrees of hardness, from a variety which melts at 40 deg. C. or under to a modification which melts only at 100 deg. C. or over. If heated for a few hours at about 70 deg. C., it slowly hardens more and more, then changes into B. The main characteristic of Solid A is that it still is fusible and soluble in caustic soda as well as in acetone or in a mixture of alcohol and acetone.

It can be easily ground to a fine powder, and mixed with any variety of fillers, and thus become very well suited for the manufacture of molded objects.

Solid A at first sight resembles very closely B; it has the same appearance, is about of equal brittleness, but B if heated does no longer melt, although it softens and becomes rubber-like. Furthermore, B is insoluble in neutral solvents; acetone and phenol may swell it somewhat but not dissolve it. How the valuable properties of A are utilized in practice, we shall see later on.



A BAKELIZER.

In the different modifications of the bakelite process the aim in view is to produce the final product C; but in as far as C is no longer plastic, all forming, shaping, molding or mixing is carried out in the earlier stages.

This is accomplished either by transforming directly A into C in one single operation, or in other cases, specially in rapid molding processes, it is found more convenient to change A into B, then remove B from the mold, and afterward change it into C without the use of a mold. In some other case the molding or shaping process is started from B and the latter is then changed into C by the application of heat.

Whether stage C is arrived at directly from A or indirectly from B, the quickest result and the best product is obtained by heating at relatively high temperatures, say 160 deg. C. or over. But as at temperatures above 100 deg. C., A dissociates into gaseous products and causes the resulting mass to be porous and spongy, I found it necessary to heat under pressure. Without this precaution the resulting mass will be technically worthless.

If the heating occurs in closed molds or closed vessels the so developed internal pressure may be sufficient to counteract the chemical dissociation which causes porosity.

In all other cases the heating should be conducted in a so-called bakelizer as shown by sketch.

This is an apparatus consisting essentially of an inner chamber where the objects are placed and in which, by means of a suitable pump, air can be compressed to 100 or 120 pounds; this pressure is maintained during the heating. A steam-jacket heats the chamber to a temperature of 140 deg. to 180 deg. C., equivalent to about 54 pounds to 150 pounds of steam.

The higher the temperature, the shorter will be the bakelizing process, which converts everything into C.

In such cases where Bakelite is used in presence of substances which cannot stand such high temperatures as, for instance, wood, wood-pulp, or paper, somewhat lower temperatures should be used and the operation takes more time. All these conditions have to be adjusted after direct experiment for each different material. For substances like asbestos or other mineral fillers it does not matter if temperatures as high as 200 deg. C. and very long bakelizing be used.

The different applications of bakelite can be divided summarily into block-working processes, impregnating processes, coating processes, and molding processes.

In some cases one or more of these processes are carried out conjunctively.

Block-working. This process suggests itself naturally to the mind and can be carried out in many ways. The simplest manner is to heat a mixture of phenols and formaldehyde under pressure in presence of a condensing or catalytic agent, say a small amount of a base. But it is more advantageous to start with one of the varieties of A described above. The A may be simply poured in a mold or mixed first with pigments, colors or suitable filling materials, for instance, asbestos, clay, mica, bone black, iron oxide, sawdust, wood pulp, finely-divided metals, mica, abrasives, graphite, etc., and thus produce an endless variety of compositions more or less suitable for certain special purposes. By heating the mass at 140 deg. to 180 deg. C. under suitably increased pressure, the whole solidifies to a solid block, which has the exact shape of the container and can easily be removed therefrom because there is a slight shrinkage. The process may take from one to two or three hours according to the size of the block, the temperature and the amount of base used. If organic fillers are used which are destroyed by too high temperatures, as for instance, wood pulp, then the minimum temperatures must be preferred and the time of heating must be increased accordingly. No such restrictions exist for mineral fillers.

The so-obtained blocks can now be sawed, cut, turned, polished, and shaped in about the same way as ivory or bone is handled.

For large blocks the following difficulty presents itself: In the final act of polymerization, the mass contracts in volume, and as it is rather difficult to carry out the heating in a sufficiently gradual manner it may happen that the crust is transformed in C before the heat has made its full action felt in the center. This may cause rents or cracks through the mass. Furthermore, C is very hard, and difficult to cut, saw, or turn. Therefore, it is easier to simply continue the heating until stage B is reached and then cut the latter to the proper shape; then B is submitted to further action of heat until it is changed into C.

I should mention that B while slightly warm is soft and somewhat elastic and cuts about as easily as Swiss cheese, yet if heated further it does not liquefy nor change its original shape. The transformation of A into B does not need to be carried out under pressure. It may be accomplished simply by heating for a few hours, at temperatures not exceeding 70 deg. C., any of the varieties of A, either in an air stove or in a water bath. The progress of the reaction can be easily followed by the touch. The A will thicken more and more until it is no longer fusible and feels elastic in about the same way as coagulated gelatine. When this stage is reached, B can be removed from its receptacle and be cut to proper shape, or the block can simply be cooled and stored away for future purposes. On cooling, B becomes hard and brittle, but if dipped in hot water it becomes soft again and regains its former elasticity.

In order to change B into C it can be heated to proper temperature in a bakelizer as described above. B is no longer attacked by hot water, as A is, and for that reason it may be simply heated in an ordinary autoclave containing water, in about the same way as rubber is vulcanized for dental purposes, with this difference, however, that higher temperatures should be used than are permissible in the rubber process.

Molds are here entirely superfluous and the objects so treated will retain perfectly their shape. Temperatures of 160 deg. C. to 170 deg. C. are quite suitable, but I have used with impunity temperatures as high as 200 deg. C. and over.

I mention this fact for persons who are acquainted with rubber vulcanizing and who are inclined to carry out bakelizing at too low temperatures or too short a time; indeed, "over-vulcanizing" is a constant menace to the rubber manufacturer.

Plates, blocks, and objects of various sizes and dimensions may thus be manufactured easily, but this process, however simple, does not commend itself in such cases where large quantities of articles of the same size have to be produced. For such purposes it is much cheaper to mold in the press, which allows quick and accurate work, without further necessity of milling or machinery or polishing. How this is done is described under the heading of molding processes.

(To be continued.)

* A paper presented at the Fifteenth General Meeting of the American Electrochemical Society at Niagara Falls, Canada, May 6th to 8th, 1909. See SUPPLEMENTS, Nos. 1768 and 1769 on Bakelite.

† See Journal Indust. and Eng. Chemistry, March, 1909, 149; Electro-chem. and Met. Ind., March, 1909, 111.

MOVING PICTURES OF MICROBES.

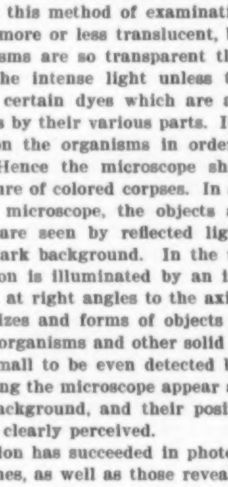
THE CHRONOPHOTOGRAPHY OF THE INVISIBLY SMALL.

BY R. VILLERS.

THE cinematograph has entered a new field. It now shows us moving pictures of a world which is invisible to the naked eye and is revealed only by the microscope. This memorable achievement has been accomplished by the ingenious experiments which have been conducted, with great patience and perseverance, during the past year, by Dr. Comandon, with the aid of apparatus furnished by Pathé Brothers, the well-known film makers.

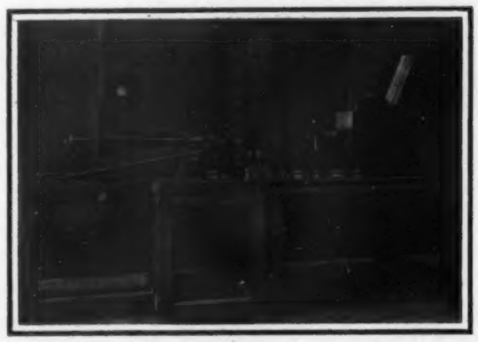
The idea was suggested to Dr. Comandon by his studies of blood parasites with the microscope and the ultramicroscope. In the classical method of microscopic examination the object is placed on the stage of the microscope and illuminated from beneath, so that the light which passes through the instruments to the eye has already traversed the object, the details of which appear in black on a bright background. It is necessary for this method of examination that the object shall be more or less translucent, but most microscopic organisms are so transparent that they cannot be seen in the intense light unless they have been stained with certain dyes which are absorbed to different degrees by their various parts. It is often necessary to poison the organisms in order to keep them motionless. Hence the microscope shows merely an enlarged picture of colored corpses. In another method of using the microscope, the objects are illuminated from above, are seen by reflected light, and appear bright on a dark background. In the ultramicroscope the preparation is illuminated by an intense beam of light incident at right angles to the axis of the instrument. The sizes and forms of objects are not clearly revealed, but organisms and other solid particles which are far too small to be even detected by the ordinary method of using the microscope appear as bright points on a black background, and their position and movements can be clearly perceived.

Dr. Comandon has succeeded in photographing these animated scenes, as well as those revealed by the ordinary microscope, and in reproducing them as moving pictures projected on a screen. The method of accomplishing this result was indicated by Victor Henri, who had already employed this method in studying "Brownian molecular movements." These moving pictures of microscopic and ultramicroscopic scenes transport the observer to a new and strange world. A tadpole's tail appears as a mass of cells traversed by a river of blood, in which the oval blood corpuscles are whirled along like pebbles in a swollen mountain brook. A drop of bird's blood, photographed by reflected light, shows elongated red corpuscles drifting slowly in a liquid filled with minute white specks.



PART OF POSITIVE FILM, SHOWING BLOOD OF A HEN INFECTED WITH SPIROCHETES

These are globules of oil, and their presence in the blood indicates that the bird had eaten fatty food a few hours before the blood was drawn. In some parts of South America the poultry yards are decimated by the ravages of *Spirochetes gallinarum*, a blood parasite which is nearly related to the germ of syphilis. In the magnified moving picture of the blood of an infected fowl these parasites are seen as corkscrew-shaped objects moving rapidly among the blood corpuscles, in the manner of eels, but backward as well as forward. Sometimes one passes through another, and chains of two or three spirals, joined end to end, are formed. Suddenly, one of the quickly-moving corkscrews enters a hole in a deteriorated red corpuscle and remains imprisoned, twisting and turning violently in a vain effort to find the outlet. Others follow it into the trap, but succeed in making their escape. A large white corpuscle, moving slowly in the manner of an amœba, encounters a deteriorated red corpuscle, which it envelops and proceeds to devour or absorb. The dark background of this strange scene is dotted with bright oil globules.



APPARATUS FOR MAKING MOVING PICTURES OF MICROSCOPIC OBJECTS.

A drop of the blood of a mouse infected with a trypanosome nearly related to the germ of the sleeping sickness is shown in another series of moving pictures. The actual length of the trypanosomes ranges from 1/1,250 to 1/250 inch, but on the screen they appear like giant caterpillars a foot or more in length. They advance somewhat in the manner of caterpillars, by the undulating movements of a special membrane. The body is swollen at the posterior end and sharply pointed in front. The swiftly-moving trypanosomes collide violently with the red blood corpuscles which, like rubber balls, are indented by the shock but instantly regain their normal spherical shape.

These few examples must suffice to illustrate the great scientific interest of Dr. Comandon's projections. These superb moving pictures of an invisible world can be studied at leisure and repeatedly, with the attention devoted entirely to the phenomena under observation. In the ordinary method of microscopic study, the observer must simultaneously examine the object, keep it in focus, and draw and describe it as accurately as is possible in such conditions. The moving pictures also afford an admirable means of teaching.

The apparatus by which these films are produced is shown in an accompanying illustration. A small and intense pencil of light, produced by a 30-ampere electric arc lamp, is concentrated upon the object by a closely-stopped lens, either directly or (in ultramicroscopic work) by means of a mirror which reflects the beam in a direction perpendicular to the axis of the instrument. The microscope is placed horizontally and projects a real magnified image of the object upon the strip of film which moves intermittently behind it. A small hole in the back of the camera allows the image projected on the translucent film to be observed with a magnifying glass, so that the focus can be adjusted and the position of the object in the field altered as may be required.

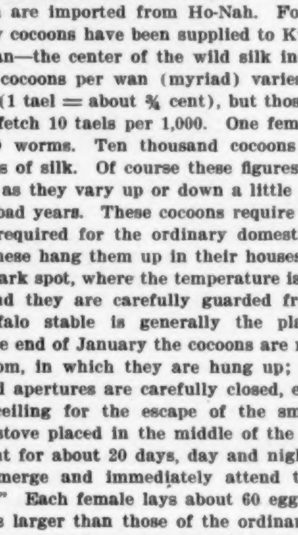
One of the greatest difficulties encountered by Dr. Comandon was caused by the heating effect of the powerful beam of light, which killed many micro-organisms in a few seconds. This difficulty was overcome by interposing, in the path of the beam, a disk with alternate sectors cut out, and causing the disk to rotate in synchronism with the cinematograph, so that the preparation is illuminated only during the actual exposures of the film and the light is cut off during the intermediate and equal intervals (1/32 inch) which are occupied in moving the film. The rays also pass through a glass cell traversed by a current of cold water which absorbs much of the non-luminous but strongly heating radiations.

A magnification of 10,000 diameters is obtained by this method. With this enlargement a flea, if it could be shown entire on the screen, would appear as large as a six-story house.—La Nature.

The following method of painting a cement wall was described at a recent convention of Canadian master painters: The building had become discolored in places, and the joints were of a different color from the surface of the blocks. Two parts of Portland cement, together with one part of marble dust, were mixed with water to the consistency of thin paint or a thick whitewash. The wall was well wetted before the application of this paint and kept constantly wet while the material was applied, and then kept for a day in order to make the cement wash adhere to the cement surface. The wash was applied with ordinary whitewash or calcimine brushes, and a man was kept busy playing a spray on it while the work was being done. The whole secret of success lay in keeping the wall constantly wet.

CHINESE WILD SILK.

WILD or so-called "mountain" silk is produced by the oak bombyx (*Antherea Pernyi*) silkworm, the eggs of which are imported from Ho-Nah. For some time past only cocoons have been supplied to Kweh-Chu and Tze-Chuan—the center of the wild silk industry. The price of cocoons per wan (myriad) varies from 30 to 33 taels (1 tael = about ¾ cent), but those containing females fetch 10 taels per 1,000. One female produces about 40 worms. Ten thousand cocoons yield about 10 ounces of silk. Of course these figures are only an average, as they vary up or down a little according to good or bad years. These cocoons require greater care than is required for the ordinary domestic silkworm. The Chinese hang them up in their houses, choosing a humid, dark spot, where the temperature is always constant, and they are carefully guarded from the sun. The buffalo stable is generally the place selected. About the end of January the cocoons are removed to a large room, in which they are hung up; all the windows and apertures are carefully closed, except a hole in the ceiling for the escape of the smoke from a wooden stove placed in the middle of the room. It is left alight for about 20 days, day and night, when the moths emerge and immediately attend to "domestic business." Each female lays about 60 eggs, which are ten times larger than those of the ordinary silkworm. The worms (which are born in about 15 to 20 days) are collected in baskets, and taken to the mountains where the dwarf oaks (*Cudrania triloba*, Hance) grow upon the leaves of which the worms feed. For 60 days the worms continue to grow, and they then spin their cocoons, the silk from which is wound off and spun toward the end of May. The chief centers of production of wild silk are the towns of Ki-Kiang, Fu-kwang-pa, and Tohe-ho-Chen in Se-Chuan, and the towns of Tseng-yi-fu, Ma-Chen, Miao-t'ang, Ngan-tse-ki, and Tseng-Ngan in Kweh-Chu. There are two qualities—



PART OF NEGATIVE FILM, SHOWING BLOOD OF A MOUSE INFECTED WITH TRYPANOSOMES.

"coarse" and "fine"; the former is made from a thread formed from 20 cocoons, and the fine from one from 8 cocoons. The price varies, but is usually about 340 taels per picul, but a couple of years ago it was 225 taels; it depends upon quantity and quality; fine silk is from 10 to 15 taels dearer than the coarse.

This "wild silk," which is known in Europe as "watereel," is sent to France, where it is milled (at Lyons and Avignon) and then sent to America, where it is made up into a stuff called "rajah." It is also now being largely used in aeronautics for the manufacture of gas bags, for which the silk is found to be highly suitable, owing to its tenacity.

MICROSCOPIC TREE-FUNGI.*

SOME MINUTE PARASITES.

BY JAMES SCOTT

THE great hindrance to the study of the microscopic fungi is their objectionable character to the naked eye and their frequently obnoxious odors. A piece of rotting twig, cabbage stalk, or some comestible may carry immense quantities of exceptionally interesting fungi, but there is little persuasion toward studying them when it is found necessary to handle the disgusting stuff. Moreover, another disadvantage that tends to keep fungi in the background is that, owing to their universally delicate structure—a mere touch is often sufficient to demolish a symmetrical group—they cannot all be purchased as mounted specimens on microscopical slides.

The following examples of microscopic tree-fungi are grouped together because they were all obtained at the same time from the same pieces of twig, etc. In addition to picturing the fungi as nearly natural size as possible in the smaller circles, it may be advisable to regard the circles as enlarged pinholes, Nos. 3, 5, 6, and 8, representing those made with the point, and Nos. 1, 4, 9, 10, and 12 with the shaft of a 1½-inch pin. In other words, the first circles are with a 1¼-inch objective, and the second ones with a ½-inch objective.

The genus, of which *Botrytis cinerea* is a good example, has several representatives that are parasitic on garden and farm vegetation. This particular specimen has simply branched, dark olive stalks, along which ashy, or gray, bunches of spores are arranged as shown in No. 1. The style of secondary branching by which the spores adhere to the stalks can be understood by referring to the right-hand space of the figure.

The coral spot fungi (No. 2) are great pests to the fruit grower. They are, in themselves, very pretty objects, and dot the stems and trunks with bright red, densely scattered warts like small seeds. There is a great similarity between the various species, and the typical genus depicted in the figure may be regarded as representing them all. In their first stages they are bright colored, and discharge their spores irregularly; but in their second stages they become rather dull in tint, and the spores are arranged in pear-shaped *perithecia* clustered together. In reality, a *nectria* splits gradually into these *perithecia*. A hole in the summit of each of the latter allows for the liberation of the spores. The majority of forest trees are open to the attacks of these compact fungi.

One of the most delicate kinds of fungi is that displayed in No. 3. Fairly long, slender, unbranched stalks support at their summits either one, two, three, four, five, or six individually divided spores. Usually the number is three. The spores are jerked off, when ripe, by the corkscrewing of the stalks. To the naked eye this fungus appears as scattered white, glistening patches, each patch composing what, in reality, is a miniature thicket. This specimen is *Trichothecium obovatum*.

Another very different style of white fungus is the *Volutella ciliata*, in No. 4. To the unaided sight it might, on account of its mealy appearance, be mistaken for the last-mentioned example, though no experienced microscopist would be thus deceived. The whole dot is really a spore-case, and is strongly defended against the attacks of mites by numerous stiff bayonet-like projections pointing in all directions.

The group of which the present *Torula pulveracea* (No. 5) is a good example may be appropriately called necklace fungi. The transparent spores are set end to end in tree-like tufts, as shown. Of course, each spore is capable of setting up a whole *mycelium* bed on its own account in a suitable *nidus*, and so it gains over many more elaborately contrived fungi in that it is practically all seed, so to speak.

The *Pistillaria* are club-shaped fungi, strikingly resembling the *Clavaria*. Indeed, the chief differences are those of size, the first being minute, and the second of much larger dimensions. *Pistillaria puberula*, which I picture in No. 6, has a powdery white sporophore, or club. One member of this genus, *P. micans*, is a beautiful glossy, rose-colored object that is most charming under the microscope.

The specimens that I exhibit in No. 7 are so widely classed as fungi by naturalists and are so common that a few words should be given concerning them. They appear like tiny collections of twisted faintly golden, or pale brown, hair emanating from scattered parts of the wood. When moistened, they wriggle about like a nest of serpents, and liberate dust which apparently consists of spores; yet Mr. W. B. Grove, a mycologist of much experience, tells me that they are simply outgrowths due to the attacks of mites.

The genus *Isaria* are minute prickly or mealy fungi, as can be seen by referring to No. 8. Rough projections get thickly covered with variously directed stiff, pin-like objects, the heads of which are the spores. Color is the chief distinguishing feature of this genus, and it is not necessary to go further into their usually simple structure.

The *Myxomycetes* are, by many of the advanced cryptogamists, considered as quite distinct from the true fungi. In the present instance, however, it will not be a very perfidious act if I regard them as belonging to the subject, in conformity with the opinions of older naturalists. No. 9 is an example having either dark brown or black stalks and fluffy, globular heads of a grayish or whitish tint. No. 11 depicts another specimen covered with a parasitic fungus allied to the *Penicillium*, or blue molds.

A *Dendryphium* is given in No. 10, in which the transparent spores are pale green when flattened between slips, but appear very dark previously. The particular style of the genus can be gathered by noting the method of growth and the positions of the divided spores, one of which is magnified to greater proportions at the side of the circle.

A rather curious Y-branched fungus is the *Sporodinia dichotoma*. The pearl-like spore-heads occupy the extreme tips of the rusty brown plant, as a rule, but frequently at the bases another form of reproduction, often to be encountered also in the *Mucorini*, or pin-fungi, comes into operation. Two or more spore-cases meet together, and ultimately coalesce, the *gametes*, as they are then called, forming a single, strong spore-cell. Sometimes one is apt to confound two or more species of fungi together when observing these stages, as they twine together like the bushes and plants of a hedgerow.

Everyone of these examples came from trees, having grown chiefly on the thinner stems and twigs. Odd broken pieces of dead trees stood in water within large glass-covered jars and left undisturbed for some days will almost surely develop many of these fungi, but it may be necessary to hunt about for some species.

The *mycelia*, or hidden threads, send up aerial stalks, or *hyphæ*, on which the varying characteristic fruits are carried.

When I examine the fungi I merely hold the stem beneath the microscope and revolve it gradually so as to bring all its circumference into the field of view. Of course, this causes the outside to appear as a horizon, from which protrude the fungi in an undisturbed condition. Some species can be transferred, with a needle, to a slide, though this plan needs great carefulness. A drop of water on the slide, into which some specimens are dropped, will assist their definition.

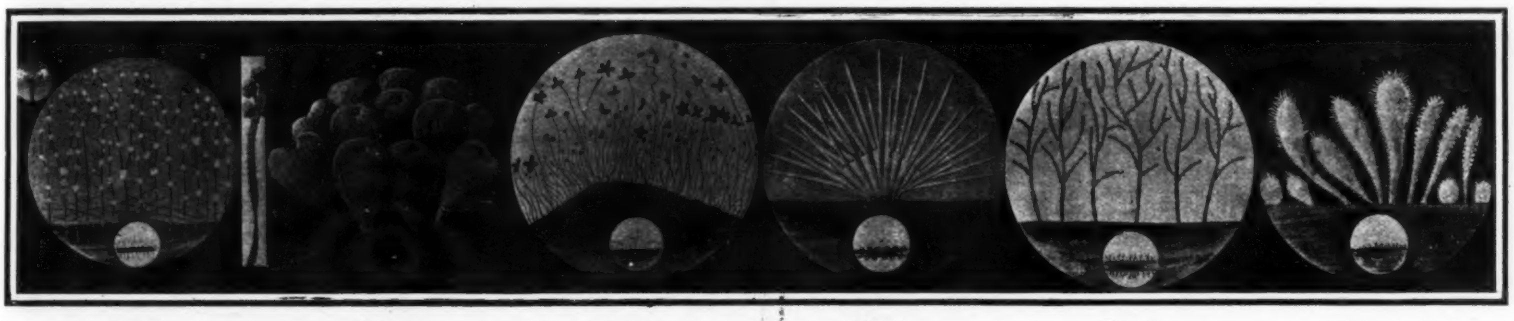


FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 5. FIG. 6.

FIG. 7. FIG 8. FIG 9. FIG. 10 FIG. 11. FIG. 12.

1. Botrytis Cinerea. The bunch spray fungus, magnified. Shown on a sixpense proportionately. A small branch is more magnified in the right-hand space; while the upper left-hand circle shows a pin-hole proportion of the growth. 2. A common "Nectria." Coral pear fungus; each mass being about the size of a pin's head. 3. Trichothecium Obovatum. The frail bead fungus, magnified. About life size in the small circle. 4. Volutella Ciliata. The spring-knob fungus, magnified. Compared also with a sixpence. 5. Torula Pulveracea. The necklace fungus, magnified. About life size in the small circle, which proportionately represents a sixpence. 6. Pistillaria Puberula. The prickly-club fungus, magnified. Shown life size on a sixpence. 7. Outgrowths due to mites. The ribbon snake fungus, magnified, and about life size on a sixpence. 8. A species of Isaria. The tiny pin fungus, magnified. Shown life size on a sixpence. 9. Common myxomycetes. The stalked globe fungus, magnified. Shown life size on a sixpence. 10. A species of Dendryphium. The divided-gem fungus, magnified. Compared also with a sixpence. To the right is shown, more highly magnified, one of the gems or spores. 11. A myxomycete covered with a parasite. The bristle-fan fungus, magnified. Shown about life size on a sixpence. 12. Sporodinia Dichotoma. The pearl fungus. Compared with a sixpence.

* Knowledge and Scientific News.

The author of an article in the Frankfürt Vulkan deals with the industrial prospects opened up by the possibility of producing pig iron electrically in considerable quantities, as demonstrated by recent successes in Sweden, where, it is stated, various works are putting the Grönwall-Lindblad-Stalham process to practical use. According to the authority named, the cost of producing pig iron by electricity is 16 per cent less than that entailed by ordinary smelting methods.

THE EFFICIENCY OF MODERN AEROPLANES.

WITH FULL DATA COLLECTED AT THE RHEIMS AVIATION MEET.

BY G. GARNIER.

AFTER the splendid success of the great aviation week at Rheims, it would seem superfluous to proclaim before the world the undeniable progress made by aviation during the last few months, and now that the general public has realized the interest in mechanical flight, we can look to the near transformation into a flourishing industry of what heretofore has been chiefly experiment in the interest of sport.

The conclusions to be drawn from the Rheims meet may be summarized and expressed in figures, thus:

Pilot's importance, 60 per cent; motor's importance, 30 per cent; importance of the machine itself, 10 per cent.

By this we mean that if, at the present time, any rationally studied apparatus is more or less apt to fly, the motors for aviation purposes are yet very precarious and that there is not one from which the same quality of performance can be expected three times in succession.

We mean also that an apparatus that has produced marvelous results in the hands of a certain pilot is, for the time being, condemned to fail or to become useless in the hands of ten other operators.

The present-day pilot must, in fact, know his machine as well as the constructor and the designer themselves know it; he must, in some sort, be capable of establishing again, by reasoning and scientific means, not by routine or from memory, the data concerning it; besides, he must be a good mechanic, in order to get out of present-day motors all they can yield; and lastly, he has to be a good air navigator, knowing how to watch the movements and variations of his machine, and to feel it by instinct, so to speak.

We may be attributing to the pilot an extraordinary importance; but we do not, however, exaggerate when we state that from him the builders have principally to expect the daily improvements that will enable amateurs gradually to learn how to manage an aeroplane, just as they manage now a 50-horse-power automobile.

But there is another lesson to be learned from the Rheims meet, for this is the first time that we have come into possession of serious information, enabling us to make a comparative study of the different types of aeroplanes, on essentially different trials, such as endurance, speed, and weight carrying. At Rheims these tests were respectively the Grand Prix de Champagne; Bennett Cup race and speed prize; and the passenger-carrying prize.

In order to render comparisons easier we will make use of the expression: "Coefficient of utilization of an aeroplane." (Revue de l'Association Générale Automobile, Jan., 1909.)

In practice, what is asked, and specially what will be asked of an aeroplane, is to carry the maximum useful load with the minimum dead weight, at the highest speed, and with the minimum of propelling power (in other words, of expenditure of energy).

If therefore we call—

P_u = the useful load (pilot and passengers or merchandise);

P_t = the total weight (including the useful load, the machine complete with supplies of gasoline, oil, and water necessary to perform a given journey);

V = the velocity (in kilometers per hour or in meters per second);

M = the effective driving horse-power

—we have for the coefficient of utilization:

$$U = \frac{P_u}{P_t} \times \frac{V}{M}$$

Let us now study the results obtained by the different types of aeroplanes in the three great kinds of trials to which they were submitted at Rheims:

I.—Grand Prize of Champagne.—In this test of endurance each contestant started with the maximum quantity of fuel that he thought should be carried. The only useful load in this instance was therefore the pilot himself.

We have collected in the following table the data necessary to calculate the coefficient of utilization.

The Wright biplanes, which were operated by the two Wright pilots, Count de Lambert and Mons. Paul Tissandier, rank first from the point of view of useful load carried. This is not surprising, considering its very low resistance to advance and the excellent efficiency insured by its two relatively slowly-revolving propellers.

It is also worthy of notice that these two machines, similar in every respect, have developed the same speed when operated by two different pilots.

The two "Antoinette" monoplanes, both piloted by Mons. Hubert Latham, come next. The proportion of useful load to total weight with these monoplanes is one-third less than with the Wright biplanes. This is due to the "Antoinette's" motor having a greater weight per horse-power than the Wright, 4.7 kilogrammes (10.36 pounds), instead of 3.6 kilogrammes (7.93 pounds); also to the single propeller, turning at 1,100 r.p.m, which gives only 265 pounds pull and seems to work under some disadvantage, by comparison with more slowly-revolving propellers; lastly, to the fact that the position of this propeller in front of the plane diminishes the lift, while the stationary horizontal and vertical fins forming a tail absorb a certain amount of power, which is compensated for, nevertheless, by a greater stability in flying.

that of the pilot; the supplies of gasoline, oil, and water had been reduced to the strict minimum for

The "Blériot XI." of the cross-channel type (machine these two flights, 20 and 30 kilometers (12.4 and 18.6 miles) respectively.

No. 23 at Rheims), came in a good first, and that was not at all surprising, because: 1st. It was made for one person. 2nd. It was a monoplane having very little head resistance. 3rd. Its dead weight was very small. 4th. Its motor was small and light.

Curtiss's aeroplane followed closely; its total weight was nearly the same, but its head resistance was a little greater, and its higher speed required greater driving power.

Nevertheless, it must be noted that these two machines, made expressly for speed and for only one passenger, are separated only, from the point of view of practical utilization, by the inherent difference in their system of construction (biplane against monoplane).

TABLE A.—GRAND PRIZE OF CHAMPAGNE.

Rheims Classification.	Make Aeroplane and Motor.	Pilot.	Useful Load. P_u (1)		Weight of Aeroplane with Motor and Supplies.		Gasoline, Oil, Water.		Total Weight. P_t		Speed in Kilometers per Hour. V		Effective Driving Power. M	Practical Coefficient of Utilization $U = \frac{P_u}{P_t} \times \frac{V}{M}$
			Kgs.	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Klms.	Mls.	H. P.	
I.	H. Farman (Gnome motor).	H. Farman	70	154.3	420	925.9	60	132.2	550	1212.5	58.4	36.3	35	0.2123
II.	Antoinette (Antoinette motor).	H. Latham	70	154.3	390	859.8	65	143.3	525	1157.4	67.0	41.6	40	0.2233
III.	Voisin (Gnome motor).	L. Paulhan	70	154.3	420	925.9	65	143.3	555	1923.6	49.1	30.5	35	0.1765
IV.	Wright (Wright motor).	Comte de Lambert	70	154.3	350 + 30 (2)	771 6 + 66.1	50	110.2	500	1102.3	62.1	38.6	27	0.3220
V.	Antoinette (Antoinette motor).	H. Latham	70	154.3	390	859.8	65	143.3	525	1157.4	67.8	42.1	40	0.2260
VI	Wright (Wright motor).	P. Tissandier	70	154.3	350 + 30 (2)	771 6 + 66.1	50	110 2	500	1102.3	62.3	38.7	27	0.3230

[1] We take for pilots, in a general way, a uniform weight of 70 kilos (154.3 lbs.), the small differences that in reality appear not being sufficient to alter the conclusions.

[2] To the true weight of the Wright machines we add here 30 kilos (66.1 lbs.); the Wright machines were indeed the only ones at Rheims that could not rise by themselves. A wheel attachment may be easily adapted to them, not exceeding this maximum weight of 30 kilos (66.1 lbs.), and hence our comparison with the other machines remains in full force.

TABLE B.—BENNETT CUP RACE.

Rheims Classification.	Make Aeroplane and Motor.	Pilot.	Useful Load. P_u		Weight of Aeroplane with Motor and Supplies.		Gasoline, Oil, Water.		Total Weight. P_t		Speed in Kilometers per Hour. V		Effective Driving Power.	Coefficient of Practical Utilization. $U = \frac{P_u}{P_t} \times \frac{V}{M}$
			Kgs.	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Klms.	Mls.	H P.	
I.	G. H. Curtiss (Curtiss motor).	G. H. Curtiss	70	154.3	230	507.1	15	33.1	315	716.5	75.7	47.0	35	0.4806
II.	Blériot XII. (E. N. V. motor).	L. Blériot	70	154.3	520	1146.4	25	55.1	615	1355.8	75.3	46.8	50	0.1714
III.	Antoinette (Antoinette motor)	H. Latham	70	154.3	390	859.8	25	55.1	485	1069.2	68.4	42.5	40	0.2468
IV.	Wright (Wright motor)	E. Lefebvre	70	154.3	350 + 30	771.6 + 66.1	20	44.1	470	1036.2	57.7	35.9	27	0.3182
French Eliminatories.	Wright (Wright motor).	P. Tissandier	70	154.3	350 + 30	771.6 + 66.1	20	44.1	470	1036.2	62.8	39.0	27	0.3464
	Voisin (Gnome motor).	L. Paulhan	70	154.3	420	925.9	15	33.1	505	1113.3	55.2	34.3	35	0.2019
	H. Farman (Vivinus motor).	R. Sommer	70	154.3	470	1036.2	20	44.1	560	1234.6	51 3	31.7	35	0.1832

TABLE C.—SPEED PRIZE.

Rheims Classification.	Make Aeroplane and Motor.	Pilot.	Useful Load. P_u		Weight of Aeroplane with Motor and Supplies.		Gasoline, Oil, Water.		Total Weight. P_t		Speed in Kilometers per Hour. V		Effective Driving Power. M	Coefficient of Practical Utilization. $U = \frac{P_u}{P_t} \times \frac{V}{M}$
			Kgs	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Kgs.	Lbs.	Klms.	Mls.	H. P	
I.	G. H. Curtiss (Curtiss motor).	G. H. Curtiss	70	154.3	230	507.1	20	44.1	320	705.5	75.0	46.6	35	0.4687
II.	Antoinette (Antoinette motor).	H. Latham	70	154.3	390	859.8	30	66.1	490	1080.3	68.9	42.8	40	0.2461
III.	Wright (Wright motor).	P. Tissandier	70	154.3	350 + 30	771.6 + 66.1	20	44.1	470	1036.2	62.1	38.6	27	0.3425
IV.	Wright (Wright motor).	Comte de Lambert	70	154.3	350 + 30	771.6 + 66.1	20	44.1	470	1036.2	62.0	38 5	27	0.3420
V.	Wright (Wright motor).	E. Lefebvre	70	154.3	350 + 30	771.6 + 66.1	20	44.1	470	1036.2	61.95	38 5	27	0 3417
VI.	Blériot XI. (Anzani motor).	L. Blériot	70	154.3	230	507.1	10	22.1	310	683.4	59.6	37.0	25	0.5383
VII.	H. Farman (Vivinus motor).	R. Sommer	70	154.3	470	1036.2	25	55.1	565	1245.6	57.6	35.8	35	0.2038
VIII.	Voisin (Gnome motor).	L. Paulhan	70	154.3	420	925.9	15	33.1	505	1113.3	54.8	34.0	25	0.2170

Mons. Henry Farman's biplane follows very closely the "Antoinette" monoplane; its head resistance is greater, but it makes up partly for this defect by the use of a very light revolving-cylinder, air-cooled motor (the "Gnome").

Mons. Paulhan's Voisin biplane comes last; its very great head resistance is the price it pays for its automatic stability and great dead weight.

II.—Bennett Cup Race and Speed Prize.—In these two speed tests the only useful load carried was again

After these two machines come the Wrights; the regularity of their useful effect is remarkable, for this type of machine, made for length of flight or for passengers, could not be expected to take first place in tests of pure speed. Their coefficients of utilization, with different pilots, are remarkably close to each other; the only apparent anomaly is in the case of

Lefebvre in the Bennett Cup race, but that is due to poor adjustment of his machine, which was never good at any time during the meeting, but which proved to be worse on the cup day; bad balancing of this machine cost him the loss of 3 to 4 miles an hour of speed.

The "Antoinette" comes after the Wright, in the same proportion as for the Grand Prize of Champagne (one-third less utilization).

Mons. Paulhan's Voisin biplane owes to its light motor the advantage gained over Mons. Royer Sommer's Farman, which was handicapped by the weight of its 35-horse-power 8-cylinder water-cooled Vivinus motor.

The "Blériot XII." (No. 22) came in a good last, but that is hardly surprising, if its dead weight and driving power are compared with those of the other machines.

TABLE D.—PASSENGER-CARRYING PRIZE.

Rheims Classification.	Make Aeroplane and Motor.	Pilot.	Passengers. Number.	Passengers. Weight.	Total Useful Load. P_u	Aeroplane Motor and Supplies.	Gasoline, Oil, Water.	Total Weight. P_t	Speed in Kilometers per Hour. V	Effective Driving Power. M	Coefficient of Utilization. $U = \frac{P_u}{P_t} \times \frac{V}{M}$
				Kgs. Lbs.	Kgs. Lbs.	Kgs. Lbs.	Kgs. Lbs.	Kgs. Lbs.	Klms. Mls.	H. P.	
I.	H. Farman (Gnome motor).	H. Farman..	2	130 286.6	200 440.9	420 925.9	15 33.1	635 1399.9	56.3 35.0	35	0.5066
II.	H. Farman (Gnome motor).	H. Farman..	1	65 143.3	135 297.6	420 925.9	15 33.1	570 1256.6	60.7 37.3	35	0.4107
III.	Wright (Wright motor).	E. Lefebvre.	1	65 143.3	135 297.6	771.6 + 66.1 / 350 + 30	20 44.1	535 1179.5	52.8 32.8	27	0.4984
At Rheims.	Blériot XII. (E. N. V. motor).	L. Blériot..	1	65 143.3	135 297.6	520 1146.4	25 55.1	680 1499.1	70 43.5	50	0.2779
At Douai.	Blériot XII. (E. N. V. motor).	L. Blériot..	2	130 286.6	200 440.9	520 1146.4	25 55.1	745 1642.4	about 65 40.4	50	0.3489
At Auvours.	Wright (Wright motor).	W. Wright.	1	110 242.5	180 [1] 396.8	350 771.6	20 44.1	550 1212.5	about 53 31.2	27	$\frac{180 - 30}{580} \times \frac{53}{27} =$ 0.5354

[1] In order to account here for the 30 kilos (66.1 lbs.) weight of a wheel system attached to the Wright machine, we deduct this 30 kilos (66.1 lbs.) from the useful weight carried, for we do not know whether the apparatus would have risen with a total weight of 580 kilos (1278.7 lbs.) instead of 550 kilos (1212.6 lbs.).

III.—Passenger-Carrying Prize.—In Table D we have added to the official Rheims results those of the "Blériot XII." at Douai and at Rheims before its destruction, and those obtained by Wilbur Wright at the Auvours field.

As for carrying passengers, Farman's biplane with two passengers on board has almost as high a coefficient of utilization as the Wright biplane (at Rheims and Auvours), with only one passenger. There is, therefore, an advantage in favor of the Wrights' aeroplanes.

Finally, the "Blériot XII.", for the same reason that we have previously given, is well behind. Its great head resistance, due to the defective disposition of the radiators, motor, and passengers, also contributes in great measure to this unsatisfactory result.

What is to be concluded from these different observations?

First of all, that at next year's meeting it will become indispensable to organize the three kinds of tests, namely: Endurance, speed, and passenger-carrying.

Consequently, builders will have to present two entirely different types: one for pure speed, the other for stability and passengers.

In short, we can even at the present time adopt for the practical utilization of existing machines, such as we have defined it at the beginning, the following classification:

High-speed aeroplanes for one person only: "Blériot XI." and Curtiss.

Aeroplanes for carrying dead weight or passengers: Wright, Farman, Antoinette, Voisin.—L'Aerophile.

NATURAL GAS.

NATURAL gas is being supplied over wider areas, and it comes as both an ally and a competitor of electric lighting. This dual position relates to both the central station and to the isolated plant, for natural gas may displace the lamps or operate the engines of either a public or private electric system, under same conditions.

As a lighting agent at the open flame natural gas has no value, but in incandescent-mantle burners it has even greater illuminating power than good manufactured gas. It is thus only in so far as mantle burners are adapted that natural gas competes with the electric light, and the most important point of such competition for central stations is probably in street lighting.

It has previously been pointed out that mantle burners with all their supposed advantages have been able to displace the open flame of manufactured gas to only a slight extent among ordinary consumers, and it may well be doubted whether natural gas can do much more in this direction. An illustration of the preference of the public for a gas that carries its own illuminating power may be noted at Buffalo, where some 600,000,000 feet of eighteen-candle artificial gas is annually sold at one dollar per thousand, though natural gas retails at thirty-two cents.

In factories and stores and on streets, however, there is some competition between natural gas and electric light, but this can often be offset by the use of gas as a source of power for electrical supply. The owner of a factory that will either operate an isolated electric plant or use natural gas for lighting finds the cost less and the service better if natural gas is burned in an engine instead of in mantles.

With mantle burners that consume only three-and-one-half cubic feet of natural gas each per hour, the volume required by eight burners will give a kilowatt-hour if used to drive a small gas engine and dynamo, and with this kilowatt-hour twenty tungsten lamps of forty candle-power each may be operated.

A central station that must compete with natural gas for lighting and power will often find itself armed for the conflict by using this gas under boilers or in engines. Though subject to some variation, the heating power of natural gas may be taken at 900 British thermal units per cubic foot, or 900,000 units per thousand cubic feet, which is approximately one-and-one-half times the heating power of ordinary manufactured gas. If a ton of 2,000 pounds of steam coal be taken to have 24,000,000 British thermal units, 26,600 feet of natural gas should make more steam than this coal, for the gas can be burned under boilers with a higher efficiency.

Even better results may be had if gas engines are used to drive the electric generators, for it would not be unreasonable to expect an efficiency of thirteen per cent, including friction losses, under reasonable conditions of load. This should give twelve per cent of the heat energy of the natural gas in the form of electric current at the dynamo terminals, or, say, thirty-one kilowatt-hours per thousand feet of the natural gas used in engines. In other words, a combined gas engine and dynamo should deliver $900,000 \times 0.12 = 108,000$ heat units per thousand feet of natural gas consumed, and 108,000 divided by 3,412, the number of equivalent heat units per kilowatt-hour, gives thirty-one kilowatt-hours per thousand feet of gas.

In the wide area between Pennsylvania and Oklahoma where natural gas is sold the rates to small consumers range from about fifteen to fifty cents per thousand feet, while the rates to factories and other large users are often as low as three, five, eight, or ten cents per thousand feet. With thirty-one kilowatt-hours per thousand feet of natural gas at the rate of three cents, the fuel cost amounts to less than one-tenth cent per kilowatt-hour, and even at the rate of ten cents per thousand feet the cost of gas is no more than one-third cent per kilowatt-hour, where gas engines are used. On the basis of the above conclusion that 26,600 cubic feet of natural gas will more than equal 2,000 pounds of steam coal under boilers, the cost of this gas to replace the short ton of coal is $0.798 at the rate of three cents, and $2.66 at ten cents per thousand feet.

Where a central station is operating with a steam plant and coal for fuel, it may or may not be advisable to install gas engines for use with natural gas, according to the price of the gas and the prospect of a permanent supply. Even if the cost of natural gas used under boilers nearly equals that of coal, the saving of labor in the fire room and the ability to instantly increase or decrease the gas heat may warrant its introduction.

Of course, an electric station has a legal right to as low a rate for natural gas as any other consumer of a like amount, even though there is competition in lighting.—Electrical Review and Western Electrician.

CHARACTERISTICS OF THE PRINCIPAL AEROPLANES.

	Voisin.	Farman.	Wright.	Curtiss.	Antoinette.	Blériot, No. 12.	Blériot, No. 11.	Santos Dumont.
Weight complete, without pilot..	Kgs. 430 Lbs. 948	Kgs. 400 Lbs. 882	Kgs. 400 Lbs. 882	Kgs. 250 Lbs. 551	Kgs. 450 Lbs. 992	Kgs. 400 Lbs. 882	Kgs. 220 Lbs. 485	Kgs. 120 Lbs. 265
Surface of the planes..........	Sq. ms. 40 Sq. ft. 431	Sq. ms. 40 Sq. ft. 441	Sq. ms. 50 Sq. ft. 538	Sq. ms. 20 Sq. ft. 215	Sq. ms. 34 Sq. ft. 366	Sq. ms. 22 Sq. ft. 237	Sq. ms. 15 Sq. ft. 161	Sq. ms. 9 Sq. ft. 97
Spread..........................	Ms. 10 Ft. 32.8	Ms. 10 Ft. 32.8	Ms. 12.50 Ft. 41.01	Ms. 7.80 Ft. 25.6	Ms. 14.80 Ft. 48.6 Trapeze.	Ms. 10 Ft. 32.8	Ms. 8 Ft. 26.2	Ms. 5 Ft. 16.4
Width of plane..................	Ms. 2 Ft. 6.56	Ms. 2 Ft. 6.56	Ms. 2 Ft. 6.56	Ms. 1.40 Ft. 4.59	Ms. 3 / 2 Ft. 9.84 / 6.56	Ms. 2.20 Ft. 7.21	Ms. 2 Ft. 6.56	Ms. 1.80 Ft. 5.90
Surface of horizontal rudder Fore.....	Sq. ms. 4 Sq. ft. 43.1	Sq. ms. 4 Sq. ft. 43.1	Sq. ms. 8 Sq. ft. 86.1	Sq. ms. 4.50 Sq. ft. 48.5	Sq. ms. Sq. ft.	Sq. ms. 2.50 Sq. ft. 26.9	Sq. ms. Sq. ft.	Sq. m. Sq. ft. ...
Surface of horizontal rudder Aft......	..	......	......	...	1 10.8	... ..	1.30 14.0	1.20 12.9
Lateral stability	Automatic.	Wing Tips.	Warping.	Balancing.	Warping.	Warping.	Warping.	Warping.
Surface aft fins................	Sq. ms. 9 Sq. ft. 96.9	Sq. ms. 8 Sq. ft. 86.1	Sq. ms. Sq. ft. No fins.	Sq. ms. 2.50 Sq. ft. 26.9	Sq. ms. 4.50 Sq. ft. 48.5	Sq. ms. 2 Sq. ft. 21.5	Sq. ms. 1.50 Sq. ft. 16.1	Sq. ms. Sq. ft. No fixed fins.
Total length of the machine.	Ms. 10.50 Ft. 34.4	Ms. 14 Ft. 45.9	Ms. 9 Ft. 29.5	Ms. 8 Ft. 26.2	Ms. 10.20 Ft. 33.5	Ms. 10 Ft. 32.8	Ms. 8 Ft. 26.2	Ms. 6 Ft. 19.7
Propeller Wood .... Diam.	...	2.60 8.5	two 2.60 8.5	1.80 5.9	......	2.80 9.2	2.10 6.89	2.10 6.89
Propeller Metal .... "	2.30 7.5	......	....	......	2.20 7.2	......	......	....
Propeller, pitch of.	1.40 4.6	......	3.75 10.6	......	1.30 4.3	3 9.8	0.80 2.6	1 3.3
Propeller, number revolutions of.	1200	1200	420	1600	1200	600	1450	1400
Horse power of motor...........	Gnome. 50	Gnome. 50	Wright. 30	Curtiss. 40	Antoinette. 55	E. N. V. 60	Anzani. 25	Darracq. 30
Number of cylinders............	7	7	4	8	8	8	3	2
Bore....	Mm. 110 Ins. 4.33	Mm. 110 Ins. 4.33	Mm. 112 Ins. 4.41	Mm. 90 Ins. 3.54	Mm. 110 Ins. 4.33	Mm. 105 Ins. 4.13	Mm. 105 Ins. 4.13	Mm. 130 Ins. 5.12
Stroke...........	120 4.72	120 4.72	100 3.94	100 3.94	105 4.13	110 4.33	130 5.12	120 4.72
Number of revolutions	1200	1200	1400	1600	1200	1500	1450	1400
Cooling...................	Air.	Air.	Water.	Water.	Water.	Water.	Air.	Water.
Speed in kilometers (Rheims results)....	Klms. 56 Mls. 34.8	Klms. 66 Mls. 41	Klms. 70 Mls. 43.5	Klms. 78 Mls. 48.5	Klms. 71 Mls. 44.1	Klms. 79 Mls. 49.1 Record.	Klms. 55 Mls. 34.2	Klms. Mls. ......

THE VACUUM BOTTLE.

WHY will the liquid in a vacuum bottle, or in any other vessel, remain cold three times as long as the same liquid will remain hot?

Power and the Engineer says the reason why can best be explained by a water analogy. First, perhaps, a little study of relative temperature is necessary.

If, on a hot day, with the mercury at 92 deg. F., a freezing liquid (32 deg. F.) be put into a vessel, the liquid's temperature must rise 60 deg. in order to reach the temperature of the surrounding atmosphere. If, on the other hand, a boiling liquid (212 deg. F.) be placed in a vessel with the outside temperature at the freezing point (32 deg. F.), the liquid's temperature must drop 180 deg. to reach the atmospheric temperature. Thus a hot liquid on a cold day has three times the difference in temperature between itself and the surrounding air, that a cold liquid has on a hot day.

And now comes the application of the water comparison. As every engineer knows, or should know, the pressure of water varies directly as the "head." Thus the pressure of a three-foot column is three times as great as that of a one-foot column. Heat acts the same way. The difference of 180 deg. exerts three times the pressure, or tendency to change, that a temperature difference of 60 deg. does. Thus the 180-degree change will take place in one-third the time required for the 60-degree change.

It may also be well to remember that cold is merely an absence of heat. Thus when a body becomes cooler, the heat is leaving it, and when it becomes warmer heat is entering it. Also, under equal conditions, heat will enter or leave a body at identically the same rate of speed.

The rapid progress of aviation has caused attention to be drawn from a new direction to the dangers of atmospheric electricity. In an article in the Elektrotechnische Zeitschrift Mr. L. Zehnder discusses the danger to balloons and aeroplanes of electrical disturbances, and the methods of avoiding disastrous effects. He points out that the electrical conditions of the air are subject to great variations during thunderstorms and that the atmospheric charges may change suddenly in sign. In clear weather an ordinary balloon without metal parts is not exposed to any danger so long as it floats in the air; but in the modern dirigibles much of the framework consists of conducting materials, which add to the danger. Also a balloon may be charged with electricity and a spark produced when contact with the ground is made, setting fire to the gas.

ENGINEERING NOTES.

Dakar is one of the few roadsteads on the West African coast which it has been found possible, without prohibitive expense, to convert into a port. It has, of course, natural advantages, such as its geographical position as a port of call for vessels running to South American and West African ports and the shelter afforded by the Cape Verde peninsula. To convert it into a port, the works designed, on the commercial side, consisted of inclosing the harbor by two masonry moles; constructing two masonry piers, each 325 yards long and 260 feet and 325 feet wide respectively, and quays connecting the piers of a total length of 2,235 yards, of which 783 yards have a depth of 26 feet and 1,452 yards a depth of over 21 feet alongside; reclaiming nearly 52 acres of ground behind the quays, dredging two basins, one to a depth of 26 feet and the other to a depth of over 21 feet (minimum depth at low springs); and, lastly, providing such accessory works as sheds, landing places, machinery, and a water supply. The work was begun in 1904, and, except for the installation of electric light and cranes, it may now be regarded as practically completed.

In a recent paper Prof. W. H. Watkinson quoted the figures of Mr. Longridge as showing that gas engines are 50 per cent less liable to breakdowns than steam engines, these figures being obtained from trustworthy insurance data. The figures have so often been accepted as showing the superior reliability of the gas engine as compared with the steam engine, states a contemporary, that it seems necessary to point out that such a comparison is apt to be misleading. In the first place, the average size of the gas engines insured is usually considerably less than that of the steam engines, and the large gas engines are notoriously much less reliable than small ones. Indeed, the small gas engine is generally a very reliable machine, and requires but little attention. Our best firms of gas engine makers put their highest efforts into these small machines. On the other hand, our contemporary maintains, the smaller steam engines are not usually so well designed or made, and they are so simple to run that, as a rule, they receive the scantiest of attention. As things are in practice, the small gas engine is probably more reliable than the small steam engine, but the reverse is probably true of large engines. That, at least, is the opinion of many insurance engineers.

A remarkable high-speed run of regular passenger trains is being made by the Great Western Railway of England, in connection with transporting the passengers of the Cunard liners from Fishguard to London. The total distance from Fishguard to London is 261 miles, a distance which was covered, on August 30th, in 268 minutes by the special mail train, and 276 minutes by a passenger train consisting of ten cars, and weighing 274 tons. The first part of the run is a difficult one, owing to heavy grades, including one, over a mile in length, of 1 in 50. The latter part of the run, however, presents more favorable conditions and the run from Carmarthen to London, a distance of 230 miles, was made in 228 minutes, including a stop of four minutes. At one section 75 miles was actually covered in 60 minutes, and 100 miles were covered in 83 minutes 49 seconds, a remarkable performance with so heavy a load behind the tender. The locomotive pulling the train was a four-cylinder, non-compound, six-wheel coupled engine weighing 75½ tons, cylinders 14¼ by 26 inches, working pressure 225 pounds, and with driving wheels 80½ inches in diameter.—Machinery.

As might be expected, papers read on traction subjects are very numerous in engineering "proceedings," and, as in this country, the question of energy consumption on cars has come to the front. Quite recently a paper on the subject, read apparently with the view of putting forward the claims of the mercury motor meter for this class of work, produced an interesting discussion. Thus, it appears that seven trips, under test conditions, on the loop and metropolitan sections of the West Side Company, Chicago, showed energy consumptions of 3.67 and 2.30 kilowatt-hours per car mile respectively, using a 33-ton motor car and 16-ton trailer. Seven carelessly-driven trips showed energy consumptions of 4.29 and 2.90 kilowatt-hours respectively. An average gain of 2 per cent in time and an excess of energy consumption of 26 per cent occurred in the last seven trips. The higher energy consumption on the loop was due to frequent stopping and starting. In view of the above, the operating efficiency of each motorman, as regards power consumption, will in future be entered on his record of service, a copy of each entry being sent to him. At Cleveland a series of tests of energy consumption on city and inter-urban cars, fourteen of each kind being tested, showed that, while the inter-urban cars weighed 50 per cent more than the city cars, the energy consumption of the former averaged 3.75 kilowatt-hours per car mile, against 3.84 kilowatt-hours in the latter case. This is equivalent to 88 watt-hours per ton-mile, against 125 watt-hours, the difference being due to the inter-urban stops averaging fifteen, against sixty-five in the case of the city cars.

SCIENCE NOTES.

According to a consular report dealing with the trade of Madagascar, the railway has reached Soanivana, 165 miles, whence motor cars and other vehicles take the passengers to Antananarivo, only 2¾ miles distant. The time taken from Tamatave to Tananarive is now two days, and when the railway reaches Tamatave from Brickaville the journey will be completed in one day.

Opening a discussion on positive electricity, Sir J. J. Thomson outlined the arguments which can be adduced in favor of the view that there is a natural unit of positive electricity analogous to the unit of negative, which is known as an electron. The discussion which ensued brought out clearly that at present experimental knowledge is far too indefinite to warrant acceptance of any of the various views. Experiment is in favor of the recognition of fundamental differences in behavior between positive and negative electricity which are not adequately represented by a mere difference in sign, although some mathematical physicists are still conservative enough to retain the pre-Faradaic view; but beyond this it is not safe to go.

During the past year M. Salet, of the Paris Observatory, has been investigating the possibility of observing modifications in faint stars in full daylight. Many years ago the late Prof. Cornu demonstrated experimentally that blue sky-light is strongly polarized; in pure air the proportion may attain as high a value as 80 per cent. Of course, this applies only to the diffused or scattered light which is simply sunlight reflected from the air particles. On the contrary, starlight, being intrinsic radiation proceeding direct from the celestial bodies outside our atmosphere altogether, is not polarized. Taking advantage of this fact, M. Salet places a Nicol prism before the eye-piece of the telescope; this acts as an analyzer on the polarized skylight, suppressing it from passing to the eye of the observer. The light from the star is allowed to pass with undiminished intensity, and therefore is relatively augmented in brightness from what it would be as seen without the Nicol prism. The arrangement has been tested on the meridian instrument at Paris, and it is stated that faint stars down to about the fifth magnitude have been satisfactorily observed at transit in full daylight.—Bulletin de la Société Astronomique de France.

The physicist who is also a mathematician possesses a most powerful instrument for scientific research with which many of the greatest discoveries have been made; for example, electric waves were discovered by mathematics long before they were detected in the laboratory. He has also at his command a language clear, concise, and universal, and there is no better way of detecting ambiguities and discrepancies in his ideas than by trying to express them in this language. Again, it often happens that we are not able to appreciate the full significance of some physical discovery until we have subjected it to mathematical treatment, when we find that the effect we have discovered involves other effects which have not been detected, and we are able by this means to duplicate the discovery. Thus James Thomson, starting from the fact that ice floats on water, showed that it follows by mathematics that ice can be melted and water prevented from freezing by pressure. This effect, which was at that time unknown, was afterward verified by his brother, Lord Kelvin. Multitudes of similar duplications of physical discoveries by mathematics could be quoted.

The theory (first enunciated by Clerk Maxwell) that light should exert a pressure upon any body on which it fell has been verified by Lebedew, Nichols, and Hull. From the principle of equality of action and reaction it is evident that a back pressure must be exerted upon any body which is giving out light or radiation of any kind. Prof. Poynting, in a preliminary communication to the British Association at Winnipeg, described some first measurements, made by himself and Mr. Guy Barlow, of the pressure exerted. It would not be convenient to use an incandescent body for this purpose, owing to the disturbances that would arise. Instead, a thin slip of black or bright material is exposed to radiation, its temperature rises until the loss by radiation is equal to that which it receives. A perfectly black material will suffer the pressure due to the incident radiation, and that alone, since it radiates equally on both sides—at least if it is thin enough to be sensibly affected at the same temperature on both sides. This pressure is equal to the density of the energy of the radiation E. A perfectly reflecting surface (such as silver approximates to) will experience a pressure equal to 2 E, since the beam of radiation is reversed by it, and, again, there will be no other pressure in this case, because no rise of temperature will take place. But if a metal film, blackened on one side, be taken with the black side toward the incident beam there will be an extra pressure due to the inequality of the emission from the two sides. The measurements that have been made so far agree remarkably well with the expected values. Incidentally, these results give rise to the question as to how far the measurements made on the pressure of incident radiation are affected by a source of error arising from this cause. In the discussion which followed it appeared that Prof. Hull was alive to the possibility of an error and his experiments had been carefully designed so as to exclude it.

TRADE NOTES AND FORMULÆ.

Etching Fluid for Glass (According to Reinitzer).—a. 1,000 parts water, 40 parts fluoride of sodium; 50 parts glacial vinegar. b. 1,000 parts water, 250 parts sodium fluoride, 160 to 170 parts hydrochloric acid 200 parts sulphate of potassium. c. 1,000 parts water, 1,000 parts fluoride of ammonium, 200 parts sulphuric acid, 100 parts sulphate of ammonium. d. Solution of 25 parts crystallized soda in 5 parts of fuming fluorhydric acid; equal parts of this mixture to be mixed with equal parts of glacial vinegar.

Apple Ether.—Take 100 parts of highly rectified spirits of wine, 10 parts valerianate of amyl, 1 part acetate of thyl, 2 parts aldehyde, 1 part nitrate of ethyl, 1 part chloroform, 1 part alcoholic saturated solution of oxalic acid, distilled in a glass retort. The first and last runnings are kept separate and only the middle distillate is used, which is rectified over finely cut fresh apple peels. First the ether with the apple peels should be left standing for 48 hours in a copper distilling apparatus lined on the inside.

To Etch Tin.—The design is first drawn free hand, with needle and pencil or traced with tracing paper and needle, the outlines filled in with a varnish (wax, rosin, or asphalt). Same is made fluid by means of turpentine and applied with a brush. After drying, the article is placed in dilute nitric acid, 1 : 3, taken out after 1½ to 2 hours, washed in water and dried with blotting paper. The asphalt coating is removed by heating and the tin oxide in the interstices cleaned out with the aid of silver soap and a brush.

Alloy for metal name plates is prepared by mixing 100 parts of pure molten copper, consecutively with 6 parts of magnesium, 57 parts of sal ammoniac, 18 parts of unslaked lime and 9 parts of cream of tartar, all well pulverized, the whole continuously stirred; then 15 parts of zinc or tin are added in small pieces and stirred in until the whole is perfectly melted and mixed. The alloy is allowed to stand quiet on the fire for half an hour, the surface is then skimmed and the metal poured off.

Axle Grease.—Melt half a part of soda in 4 parts of water, add 3 parts tallow and 6 parts palm oil, heat to 158 deg. to 167 deg. F., and stir the resultant fluid until it has cooled to 58 deg. to 70 deg. F. An axle grease for high-speed axles is made (1) from 1 part soap, 1 part rape oil, 5 parts water, 2 parts tallow powder; (2) brown ozokerite; petroleum 4 parts. Allen's Excelsior axle grease is made from 1.1 part of linseed oil, 1.1 part castor oil, 1 part tallow, 1 part rosin, 0.5 part of ozokerite. If the grease is too hard, add a little neat's-foot oil; if too soft, a little tallow.

To Stain Maple Wood a Dull Gray.—a. In a sufficiently large pitch-coated box place fine polishing sand, then the wood, and over this another layer of sand; pour rain water over all. Allow it to stand in a warm place for 3 to 5 weeks. b. Steep the wood for 3 to 4 hours in a decoction of gall nuts (1 part powdered gall nuts to 10 parts water), then allow it to lie for an hour in a solution of 1 part sulphate of iron (green vitriol) in 60 parts cold water; next brush it, by means of a soft brush, with alum solution (1 part of alum in 18 parts water), and allow to dry.

Maple Wine.—In spring, when the sap circulation begins to be active, bore into the trunk of a sugar maple, about 20 inches above the ground, collect the juice that flows out and mix it with some fresh white wine, that is still fermenting. After the maple sap and wine in vessels that must be kept in a place at a temperature of 68 deg. to 78 deg. F. has completed the chief fermentation it is filtered, then add ½ a part of tartaric acid and 10 parts of sugar for each 1,000 parts, and rack into champagne bottles. These must be corked and kept lying down in a cellar. After six weeks the maple wine, which effervesces like champage, is fit to drink.

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